VOL. VIII DECEMBER, 1935 No. 2

BULLETIN

OF

THE NEW YORK STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY
SAMUEL N. SPRING, *Dean*

Roosevelt Wild Life Annals

VOLUME 4 NUMBER 1

OF THE

Roosevelt Wild Life Forest Experiment Station

STUDIES ON SOME OF THE SMALL MAMMALS OF CENTRAL NEW YORK

CONTENTS OF RECENT ROOSEVELT WILD LIFE BULLETINS AND ANNALS

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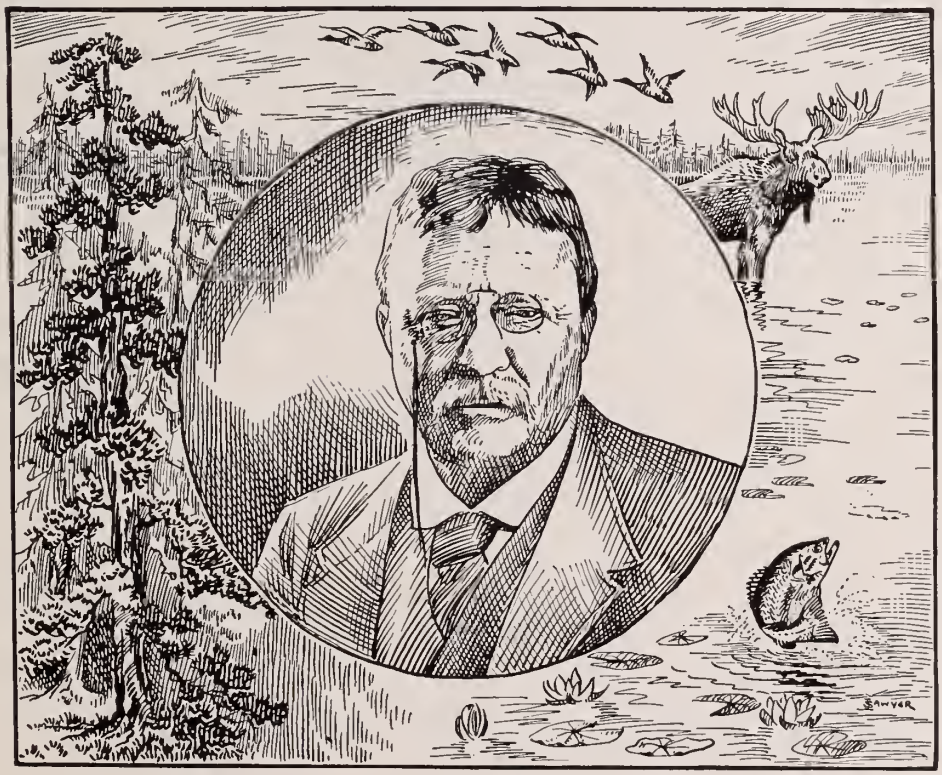

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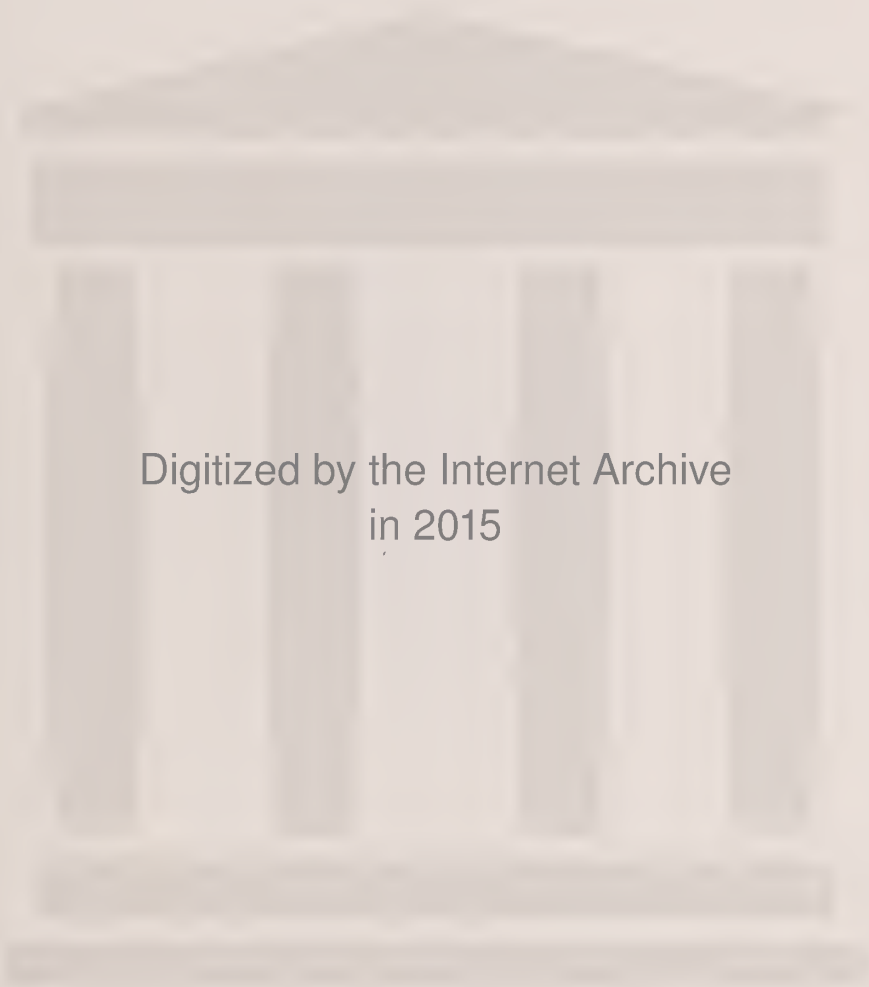


Map 1. Showing areas studied in 1931 and 1932 seasons. 1, St. Mary's Pond region (1931); 2, 3, 4, 5, North Constantia region (1932). Adapted from U. S. Topographic map.

STUDIES ON SOME OF THE SMALL MAMMALS OF CENTRAL NEW YORK

By M. T. Townsend

Field Naturalist, Roosevelt Wild Life Forest Experiment Station, Syracuse, New York

CONTENTS

PART I. INTRODUCTION

During the summer of 1930, the author was engaged by the Roosevelt Wild Life Station to begin a study of the distribution and certain phases of the biology of some of the small mammals in the region of Syracuse, N. Y. The work developed into a study in some detail of seven of the more common species with incidental observations on a few less numerous forms. The study was continued for five seasons. Field work began each year early in June and closed late in August, a new locality being chosen each season. Trapping was a main feature in the work, and for this purpose the ordinary U-lever mouse traps were used. A system of setting large numbers of these traps was developed, and during the last three seasons a thousand to eighteen hundred traps were constantly kept in operation by the author and his assistants.

Acknowledgments are due to Dr. C. E. Johnson and Mr. Wilford A. Dence of the Roosevelt Station Staff, and to Mr. LeRoy Stegeman of the department of Forest Zoology, for suggestions and help with various phases of the work; and to Dr. V. E. Shelford of the University of Illinois for the privilege of a conference during the later stages of the report. To Dr. Johnson of the Roosevelt Station and to Mr. A. H. Howell of the U. S. Biological Survey I am indebted also for help in the identification of specimens.

In the field work I had as assistants at different times Messrs. Deane Mather, Hans Bierman, John Pearce and Charles Brown, all of whom performed their duties faithfully and efficiently. Particular mention must be made of Mr. Pearce who served during three seasons. The accuracy and dependability of the trap-line data are due in great measure to his conscientious and painstaking work, and the report as a whole has felt the influence of his criticisms and suggestions.

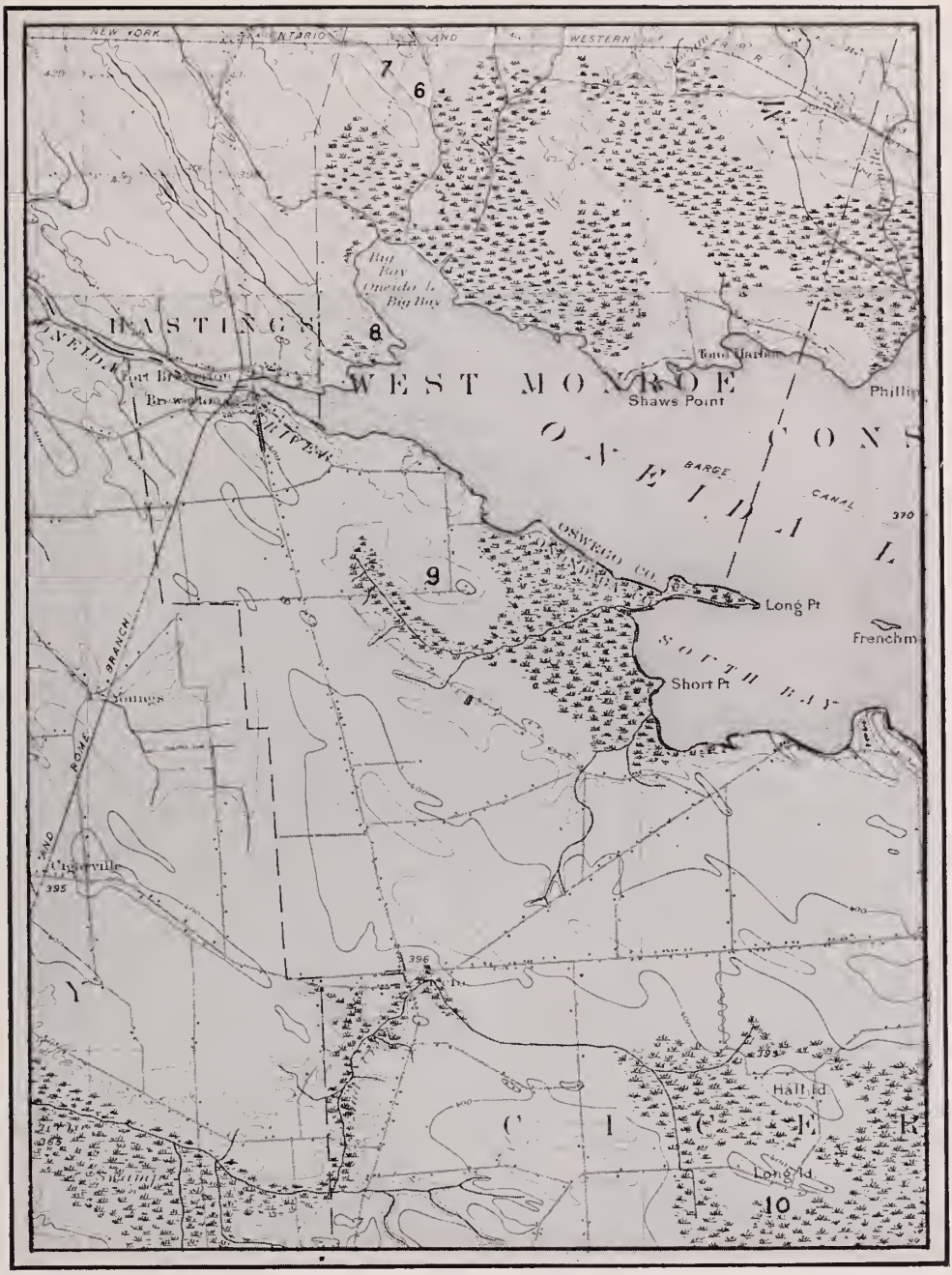
For brevity, generic designations *only* are given in many instances in the text and tables, but it will be understood that reference is made to the form or forms occurring in the region under consideration.

LOCALITIES AND SEASONS

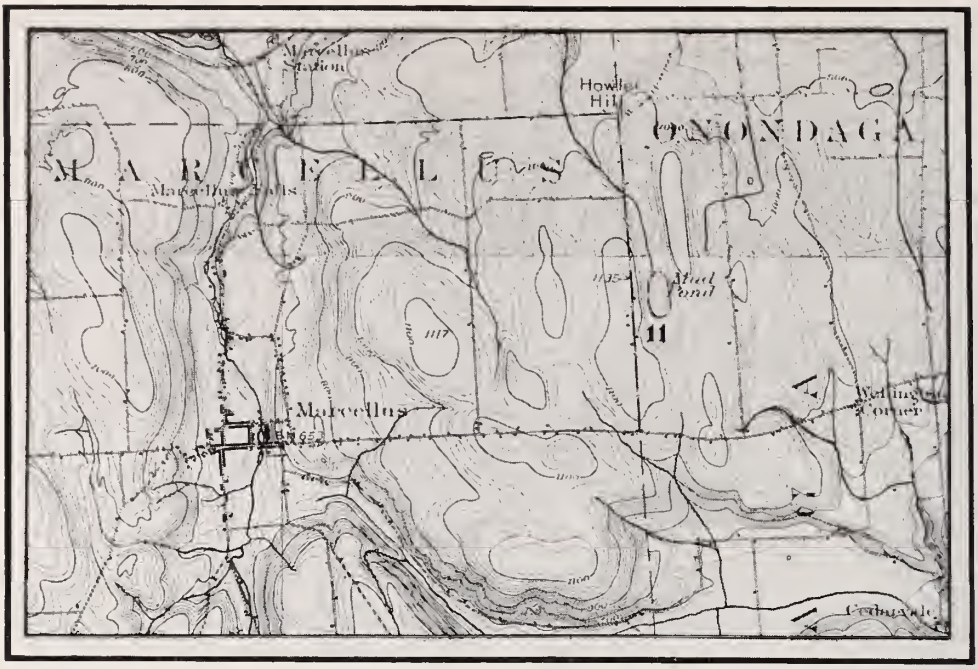
A detailed description of the habitats in which these studies were carried on, lists of vegetation characteristic of each and notes on the weather of the trapping seasons are given in the appendix, since such details will probably be of interest only to a few readers. The maps show the general location of the localities concerned.

The work of the first season, 1930, was carried on in the vicinity of Brewerton (Map 2). Most of our trapping during this season was done in or near a woodlot on Hoyt's farm, situated just north of Big Bay Swamp, in the town of West Monroe; but later in the summer some attention was devoted to a brushy swamp at Sadler's farm, about two miles southeast of Brewerton and near Long Point Swamp, and to a patch of maple woods at Cicero Swamp, just south of what is locally called "Long Island".

In 1931 the study was carried on in the town of Parish, the trapping being done around St. Mary's Pond (Map 1), a small pond surrounded by quaking



Map 2. Showing areas studied in 1930 season. 6, Little Bay Creek region; 7, Hoyt's woods; 8, west end Big Bay; 9, Sadler's woods and swamp; 10, Long Island at Cicero swamp. Adapted from U. S. Topographic map.



Map 3. Showing area studied in 1933 season, at Mud Pond, Marcellus (11).

Map 4. Showing areas studied in the 1934 season at Conquest. 12, Mud Pond region; 13, Spook Woods; 14, White's marsh. Adapted from U. S. Topographic map.

bog flanked with hardwood forest. Between the flat quaking bog and the woods was a zone of alders (see Fig. 15). Both quaking bog and alder zone were largely devoid of mammal life, but the woods beyond the alders yielded a good catch. The pond is about twelve miles from Hoyt's woods, the locality of the previous season's activity.

In 1932 the trapping was done near Constantia, on the north shore of Oneida Lake, in mixed hardwood forest along the south shore of South Pond (Station 2, Map 1) and the north shore of the nearby reservoir (Station 3, Map 1). Meadow trap lines were operated along the reservoir outlet farther to the east. Another study was made in low hardwoods on Butler's farm, about two miles due west of Panther Lake (Station 4); and a third in meadow land along Crandall Creek (Station 5), about two miles southeast of North Constantia. All the work of the 1932 season will be referred to in the rest of the paper as that of the Constantia area.

In general it may be said that the small-mammal fauna of the St. Mary's Pond and the Constantia areas are very similar. The two locations are only about five miles apart, and the habitats similar.

The location for 1933 was the area around the south shore of Mud Pond (Map 3), in the town of Marcellus, about six miles southwest of Syracuse. In general the trapping was done rather close to the pond, but one area of study was about half a mile south of the pond. Mud Pond is estimated to be about twenty-one miles from Hoyt's Woods in the Brewerton region.

In the summer of 1934 a locality was chosen near the village of Conquest (Map 4), about thirty-five miles northwest of Syracuse and about 20 miles west of Brewerton. The land here is fairly low and level, except for the rather numerous drumlins. Brooks are conspicuously absent. The drumlins gave us in some cases good examples of dry maple woods for study, while the low lands afforded meadow, marsh and moist woods. Near the "Mud Pond" of this locality an extensive area of moist woods yielded our best catches of Evotomys.

TYPES OF HABITATS

A general classification of the habitats selected is as follows:

1. **Dry Woods.**—Including the upper hillsides in the woods around St. Mary's Pond, and those around South Pond and the reservoir at Constantia; the higher ridge tops near Mud Pond at Marcellus, and the wooded drumlins near Conquest. This dry woods habitat represented a mixed growth of hardwoods, with only a moderate amount of shrubs or other ground vegetation. There was the typical leaf-mold layer; and fallen logs and small brush-piles lay scattered over the forest floor (see figs. 1 to 3).

2. **Moist Woods.**—The low woods along the edge of the alder thickets at St. Mary's Pond, and bordering the brooks inland for a short distance; the lower parts of the woods around South Pond and the Reservoir; Butler's woods, near Panther Lake; and a limited area south of Mud Pond in the town of Marcellus; also an extensive area near Mud Pond at Conquest. This type of woods is not difficult to distinguish from dry woods. The forest floor is hummocky, covered with moss, short tufts of grass and in general is hidden by

a dense growth of ferns or jewelweed. Damp mossy logs are characteristic, and the ground has decidedly more moisture than in the "dry" woods (see Fig. 5).

3. **Weed-Meadow.**—For this type areas were selected where the growth of grass and weeds was thickest and superficially appeared most likely to yield a considerable number of small mammals. The grass and weeds reached a height of a few feet; but there were no trees. These meadows were such as are left uncut by the farmer at haying time. They are in the lower "swales" and at certain seasons are decidedly moist underfoot. They might well be called "wet meadows". These habitats were found along Little Bay Creek at Brewerton, at the edge of the woods at the east end of South Pond, along the outlet from the Reservoir, and along Crandall Creek; also south of Mud Pond in the town of Marcellus, and in two localities near Conquest (see figs. 6 to 10).

4. **Woods-Meadow.**—At Sadler's woods in the Brewerton Region, and especially at the southwest corner of Mud Pond (Marcellus) we encountered a type of habitat which seemed to combine some features of both woods and meadow. Scattered clumps of hardwood and of cedar are interspersed with stretches of tall grass and weeds. The habitat in general is a moist one and it was found to yield, at times, many of the other small mammals found in the section excepting Evotomys and Napaeozapus.

5. **Minor Habitats.**—Occasionally an area of some other and more specific type of habitat was found in the territory and given some attention. Sedge and cat-tail marshes, for example, were examined at Brewerton and at Conquest, but yielded very low catches of small mammals. Old signs of Microtus were, however, frequently found here and it may be that in certain years or seasons these places would show a large meadow-mouse population.

At Mud Pond, Marcellus, a distinct zone of dogwood, just west of the pond, yielded a good catch of mammals over a period of two weeks. Just south of this Pond a patch of sweet flag was found, in which trapping was carried on for two weeks in June and again for two weeks in late August (see Fig. 17). During the intervening weeks the "flag" had been blown down almost completely and formed a dense mat of stems and leaves over the ground surface. The yield was good in both of the trapping periods mentioned and will be discussed in a later part of the paper.

The weather conditions for the five seasons of study differed, more or less, in certain respects. In 1930, the first part of the summer was unusually wet, and every stream and pond was at "high water" stage. During the last half of the season a drought occurred. At St. Mary's Pond a good many thunder showers occurred during the summer of 1931, and many days were excessively hot and humid. At Constantia, in 1932, a good deal of rain fell in June, but the latter part of the season was rather cool and dry. At Marcellus, in 1933, we experienced a summer almost without rain, very hot in early July, but generally cool otherwise. The summer of 1934 was dry and followed an exceptionally severe winter. Records of temperature were kept through the several seasons of field work, and in addition a set of atmometers was operated in the woods at St. Mary's Pond, in 1931, and at South Pond, Constantia, in 1932. The records obtained

Fig. 1. Dry maple woods on top of drumlin at Spook Woods, Conquest. Late June, 1934.

Fig. 2. The forest floor in a maple woods on top of a drumlin. Note loose character of leaf mold. Spook Woods, Conquest. Late June, 1934.

Fig. 3. Dry beech-maple woods near road to Mud Pond at Conquest. Late June, 1934.

Fig. 4. The forest floor in a region intermediate between dry woods and moist woods. Goldthread is a common herb here. North Constantia, June 28, 1932.

were studied in connection with the results of the trap lines, but no correlation was found. In general, however, it is felt that weather has a definite but brief effect on the small mammals during the summer months. No doubt warm, sultry days, or nights, have their influence in contrast with the colder periods, and doubtless also a heavy rain may temporarily influence the activities of various small mammals; but our records were not of a nature as to reveal any such possible temporary effects.

METHODS

The method of study, as previously mentioned, included the use of a thousand to eighteen hundred ordinary U-lever mouse-traps, and besides, a few live-traps of various kinds which were employed intermittently to catch a few specimens alive for cage studies. The U-lever traps were handled in lots of 99; each trap was provided with a small staple in the end of the wooden base, or a hole bored through the base, for stringing on a wire. Each lot of 99 traps was then divided into three "units" of thirty-three each, which were strung on three carrying wires, and the carrying wires each fastened to a stick for transportation in the field. On the base of each trap was a number painted in white. At the end of each two weeks of trapping the traps were taken up, cleaned, the bait-pan joint and spring oiled, and rebaited, whereupon they were reset in some other location. Traps lost in the field were replaced, so that each unit was kept up to its full complement.

Throughout the four seasons' work, traps were set in groups of three, fairly close together—approximately six inches apart, on the average—and usually in a radial fashion, bait pans outward. One of the three traps was baited with a small piece of bacon rind, the second with a half of a salted peanut, and the third with a large seedless raisin.

During the first two seasons considerable experimenting was done in the handling and disposition of the traps in the field, and as a result a standard method was evolved which was employed during the last three seasons; it proved very satisfactory for this type of study. It furnished data for analysis of a number of questions that presented themselves, as will be shown in Part two of the present report.

Briefly the method consists of using two series of traps, which here will be called the "moving quadrat" and the "stationary line" (see Plate 1). After preliminary observation trips, and perhaps the use of a number of scattered test traps, the definite trapping areas are selected, and each is provided with one moving quadrat and one stationary line of traps. The stationary line consists of a straight line of traps set in groups of three, each group being three feet from the next group. Thus the whole line of 99 traps extends for a distance of about one hundred feet through the chosen type of habitat. It remains in place fourteen days.

Several yards away from this stationary line, and arranged to lie always in the same type of habitat, is laid out a moving quadrat of ninety-nine traps. In this trap series, three short lines of thirty-three traps each are set out, parallel with each other and at right angles to the stationary line. In each line the traps are again set in groups of three, and the groups three feet apart.

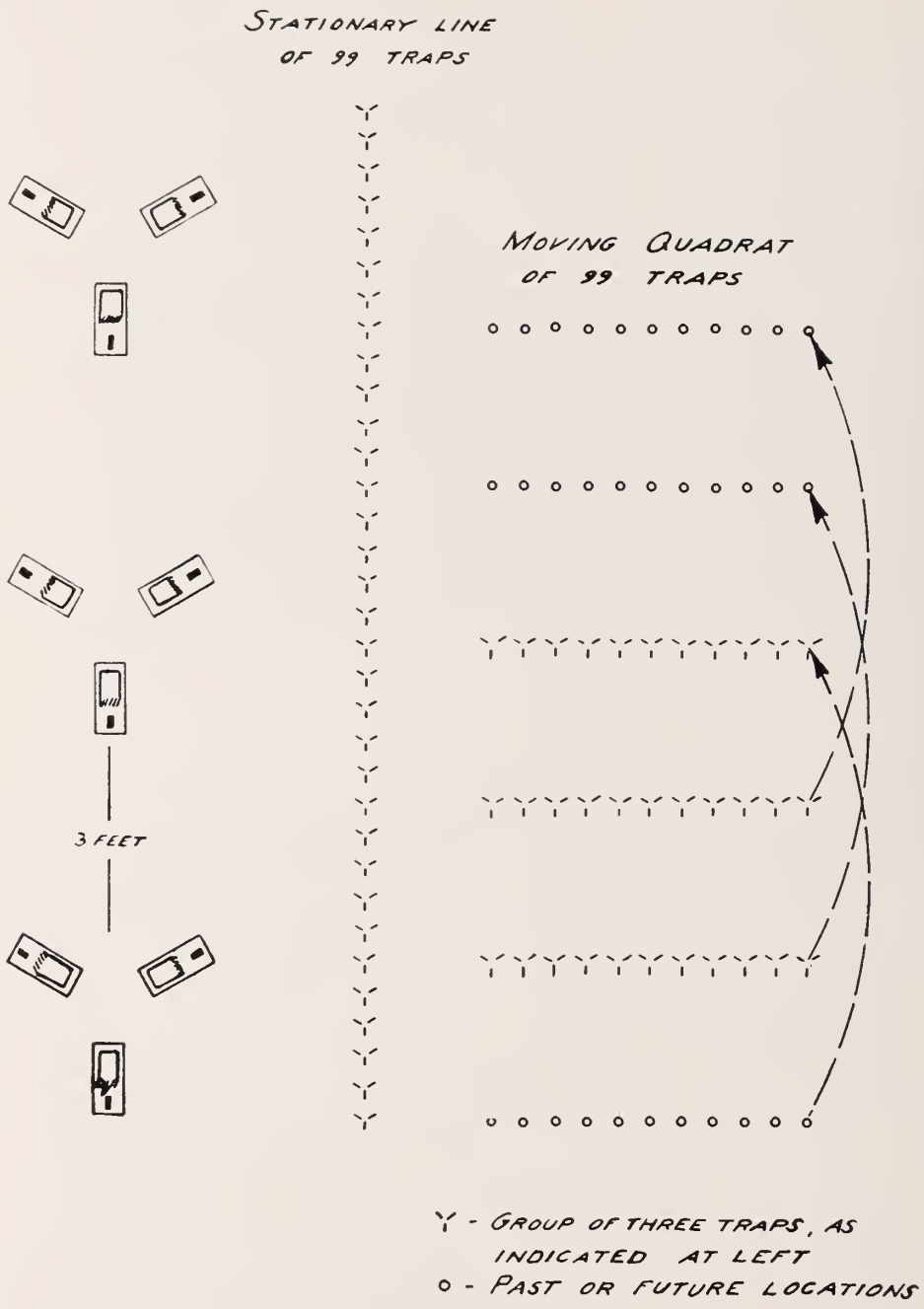


Plate 1. Showing arrangement of traps in the field. Groups of three traps are placed in the form of a stationary line or as a moving quadrat.

The three parallel lines are situated about a rod apart, the distance being paced off in routine work. The numbers of the traps are always in the same order, numbers 100, 133 and 165, for instance, all being on the base-line of the quadrat. After leaving these traps in place for 24 hours the operator starts the "moving" of the quadrat. The first line of 33 traps,—for example, numbers 100—132 inclusive—is now taken up in order and placed in a new line a rod beyond the front line. The following day the second line is moved to the front, then the third; and thus the quadrat progresses through the selected area or habitat, a line of 33 traps being placed each day a rod in advance of the other lines and parallel with them. In this field work a 14-day time period was chosen. For fourteen nights the stationary line remained in its place, while the moving quadrat was advancing a line a day through another section of the same habitat. Then all traps were collected and removed to a new habitat. As will be discussed later, in the chapter on wandering tendency, a 12-day period would seem to be better than the 14-day period for future work.

One or two features of this trapping method should be emphasized at this time. In placing the lines of traps, effort is made to keep them straight and parallel regardless of certain conditions that may exist within the area of habitat chosen. Thus, if a bare spot of ground is encountered, three traps are nevertheless placed there; if a burrow happens to lie in our path, a trap is placed in it; if a brush pile obstructs the proposed line, an effort is made to place traps at the proper interval under it; if a tuft of grass occurs, traps are set beside it or in the center of it, etc. Practically the only thing which led to a deflection of the trap lines from their determined course was an occasional tree trunk or stump; then the line passed around the obstruction. In this way our trapping represents a random sample of the habitat in all its phases, and this is important in connection with the concept of "place perception" to be discussed later.

Another feature of the trapping method was the close spacing of the traps. It will be noted that our lines were a rod apart in the moving quadrat, and in each line the trap groups of three were only three feet apart. This represents what may be termed intensive trapping and was designed to "trap out" an inhabited zone of the habitat completely. This point is important in connection with most of our major concepts, and will be referred to later as a means of eliminating certain errors which might otherwise have entered into the work. However, results during the 1933 season at Marcellus have indicated that in certain habitats containing dense growths of weeds, for example, and in a season of abundance of mice, even the above-mentioned close spacing of traps may not be adequate for the purpose.

Population (per acre) estimates enter into some phases of the work discussed later in the paper. The basis for these estimates is the assumption that each short line of 33 traps will trap out one-eightieth of an acre: Each line is 33 feet long, and the lines in the moving quadrat are placed a rod apart. Accordingly it is estimated that eight such lines trap out an area at least 33 feet by 132 feet, or 4356 square feet. This is the area of one square Gunter's chain, or 1/10 acre. One short line therefore is considered to catch the mouse population on 1/80 of an acre. Similarly one moving quadrat accounts for 7/40, or about 1/6 of an acre. This quadrat is closely comparable to the major quadrat suggested by Shelford

('29, p. 55). The major quadrat is a unit ten meters square, which is practically the equivalent of two of the present short lines. In estimating population per acre it was thought best to consider only the animals caught during the first three days, ignoring the later catches, which perhaps were due to individuals wandering into the zone after the earlier residents had been removed.

A number of observations were made upon individuals kept in cages, in camp. Usually the cages were placed among herbaceous plants, or upon the ground or in a shallow excavation. In such cages the animals are under more nearly normal conditions than if brought to the laboratory.

Observations on the trap lines were recorded in a field notebook, on sheets with columns headed as follows: Species; Bait; Trap Number; Set; Sex; Size; Date; Trap Day; Temperature; Light; Rain; General Notes.

Table 1. Record of Catches on Several "Permanent Traps" Left in Place for a Long Period; Visited Daily.

Year	Bait	Place	Date	Trap day	Catch	Sex	Trap No.
1930	Peanut	Open, near burrow	June 24	1	Blarina	?	287
			24	1½	Blarina	?	287
			25	2	Blarina	?	287
			26	3	Blarina	?	287
		(Moist woods)	July 14	21	Pitymys	M	287
			15	22	Blarina	M	287
			18	25	Blarina	F	287
1930	Bacon and raisin	Brush-pile	July 10	½	Blarina	M	206
			13	6	Blarina	M	206
			17	10	Blarina	M	206
			18	11	Blarina	F	206
			20	13	Blarina	F	206
			22	15	Blarina	M	206
			31	24	Blarina	M	206
			Aug. 1	25	Blarina	F	206
			2	26	Blarina	F	206
			5	29	Blarina	M	206
			10	34	Blarina	F	206
1933	Bacon	Burrow	June 22	14	Blarina	M	454
			28	20	Blarina	M	454
		(Cedar-meadow)	July 22	44	Microtus	M	454
			29	51	Zapus	M	454
			Aug. 4	56	Sorex	M	454
1933	Bacon	Cover (Cedar-meadow)	June 25	17	Blarina	M	490
			Aug. 10	62	Blarina	M	490
1933	Peanut	Cover	July 3	25	Sorex	M	458
1933	Raisin	Cover	July 14	36	Blarina	M	456
			Aug. 3	55	Blarina	F	456
1933	Peanut	Burrow	July 24	46	Zapus	F	404
			29	51	Microtus	?	404
1933	Bacon	Burrow	July 25	47	Blarina	F	409
			Aug. 4	56	Blarina	M	409
			14	66	Blarina	F	409
			20	72	Blarina	M	409

TABLE 2. TRAP-DAY CATCHES FOR EACH SPECIES, VARIOUS YEARS, SHOWING RELATIVE NUMBER OF ANIMALS CAUGHT ON SUCCEEDING DAYS.

DAY		STATIONARY LINE DATA														MOVING QUADRAT DATA		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3
Blarina	1931	6	9	4	6	4	2	1	3	1	0	0	1	1	3	31	25	15
	1932	12	9	16	4	5	4	1	5	3	5	2	5	6	4	47	44	36
	1933	7	6	10	10	7	11	4	7	3	8	5	8	5	6	30	28	28
	1934	7	1	4	0	4	0	0	1	3	1	5	2	0	5	9	11	9
Sorex	1931	2	3	2	1	1	1	0	1	1	1	0	1	1	1	18	12	15
	1932	2	1	3	1	3	1	0	3	2	3	2	3	1	2	9	8	16
	1933	5	8	3	5	8	12	16	0	7	7	7	9	11	3	39	36	27
	1934	4	3	2	6	4	4	5	4	2	2	3	4	2	1	12	8	14
Peromyscus	1931	3	9	3	2	1	0	1	0	2	1	0	0	0	0	33	25	28
	1932	6	3	6	3	2	0	2	4	1	2	2	0	2	0	14	10	14
	1933	5	2	2	1	3	4	2	5	3	1	4	3	0	3	33	9	12
	1934	15	6	7	3	1	5	1	2	2	1	1	2	2	2	39	20	16
Evotomys	1931	9	3	2	1	2	0	1	0	0	0	0	0	0	0	8	3	6
	1932	2	1	1	0	0	0	0	0	0	0	1	0	1	0	14	6	8
	1933	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	1934	16	6	9	3	4	9	15	6	3	8	8	1	5	3	61	32	29
Zapus	1931	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	1	0
	1932	4	2	5	0	1	3	2	1	2	4	1	3	3	0	6	6	8
	1933	3	2	0	1	1	5	1	1	3	2	7	1	2	2	13	5	12
	1934	1	4	5	2	5	5	4	0	3	1	1	0	0	2	13	9	9
Napaeozapus	1931	10	3	1	1	8	1	2	2	0	0	2	0	1	0	5	4	11
	1932	5	3	5	1	2	2	0	0	0	0	4	3	3	1	13	16	9
	1933	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	1934	..	..	..	..	1	..	..	..	..	..	..	..	1	..	0	1	3
Microtus	1931	2	1	2	0	1	1	0	0	0	0	0	0	0	0	..	..	..
	1932	1	0	0	0	0	1	0	0	1	1	0	0	0	0	3	3	0
	1933	16	6	5	8	2	6	4	5	3	5	7	4	1	3	53	24	24
	1934	7	8	2	0	2	1	1	1	1	1	0	1	0	1	24	12	10

TABLE 3. SUMMARY OF CATCHES AT BREWERTON, 1930.

Tabulated to show correlation of catch and bait. Place data not available from this season's record.

BAIT	BLARINA		SOREX		PEROMYSCUS		ZAPUS		MICROTUS	
	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.
Bacon	67	59.8	6	25.0	4	23.5	16	39.0	7	30.4
Peanut	28	25.0	18	75.0	3	17.6	18	44.0	6	26.1
Raisin	17	15.2	0	.....	10	58.9	7	17.0	10	43.5
Total	112	.....	24	.....	17	.....	41	.....	23	.....

On several occasions during the five seasons one or more traps were placed in a likely location early in the summer and kept there for a long period, visited and baited regularly and the catch recorded. These are designated as "permanent traps" or "permanent lines," as distinguished from the "stationary lines" which remain in place only 14 days. Some of the more interesting results from the permanent traps are listed in Table 1, and these show how the same trap may continue to catch something at intervals for a long time. The same may be noted by a study of Table 2, where the day-catches for all the traps during four seasons are summarized. On the stationary lines it will be noted that in many cases the largest catches were made during the first three days, but this does not always hold true, and in general a smaller catch may be expected over the entire 14-day period.

Tables 3 to 7 summarize the data from the field notebooks for five seasons and provide the source from which several later tables are derived.

TABLE 4. SUMMARY OF CATCHES AT ST. MARY'S POND, 1931.

Entire catch for the summer included. Tabulated to show the combinations of bait and trap-set which were effective in catching each species.

BAIT	Trap-set	BLARINA		SOREX		PEROMYSCUS		EVOTOMYS		ZAPUS		NAPAEOZAPUS		MICROTUS	
		Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.
Bacon	Open	5	3.9	1	1.5	15	13.0	2	4.9	.....	.....	9	17.6	2	18.2
	Cover	9	7.0	6	9.0	6	5.2	.....	.....	1	16.7	1	2.0	1	9.1
	Burrow	47	36.7	4	6.0	9	7.8	2	4.9	.....	.....	1	2.0	.....	.....
Percentage (Bacon)		.....	47.6	.....	16.5	.....	26.0	.....	9.8	.....	16.7	.....	21.6	.....	27.3
Pearut	Open	5	3.9	6	9.0	26	22.6	7	17.1	.....	.....	10	19.6	1	9.1
	Cover	7	5.5	11	16.4	12	10.4	8	19.5	1	16.7	8	15.7	1	9.1
	Burrow	42	32.8	37	52.2	5	4.4	8	19.5	.....	.....	1	2.0	1	9.1
Percentage (Peanut)		.....	42.2	.....	77.6	.....	37.4	.....	56.1	.....	16.7	.....	37.3	.....	27.3
Raisin	Open	2	1.6	.....	.....	20	17.4	5	12.2	2	33.3	10	19.6	.....	.....
	Cover	4	3.1	.....	.....	15	13.0	5	12.2	2	33.3	9	17.6	5	45.4
	Burrow	7	5.4	2	2.9	7	6.1	4	9.7	.....	.....	2	3.9	.....	.....
Percentage (Raisin)		.....	10.1	.....	2.9	.....	36.5	.....	34.1	.....	66.6	.....	41.1	.....	45.4
Total catches		128	.....	67	.....	115	.....	41	.....	6	.....	51	.....	11	.....

TABLE 5. SUMMARY OF CATCHES AT CONSTANTIA, 1932.

Entire catch for the season included. Tabulated to show the combinations of bait and trap-set which were effective in catching each species.

BAIT	Trap-set	BLARINA		SOREX		PEROMYSCUS		EVOTOMYS		ZAPUS		NAPAEOZAPUS		MICROTUS	
		Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.
Bacon	Open	25	10.9	4	6.4	13	19.1	3	8.7	4	7.5	9	13.2	.....	.....
	Cover	13	5.7	2	3.2	11	16.2	1	2.8	7	13.2	7	10.3	4	28.6
	Burrow	76	33.0	11	17.7	4	5.9	1	2.8	.....	.....	2	2.9	3	21.4
Percentage (Bacon)		.....	49.6	.....	27.3	.....	41.2	.....	14.3	.....	20.7	.....	26.4	.....	50.0
Peanut	Open	19	8.2	13	21.0	14	20.6	9	25.7	4	7.5	9	13.2	1	7.1
	Cover	14	6.1	8	12.9	8	11.8	7	20.0	12	22.6	5	7.4	2	14.3
	Barrow	57	24.8	13	21.0	3	4.4	6	17.1	2	3.8	3	4.4	.....	.....
Percentage (Peanut)		.....	39.1	.....	54.9	.....	36.8	.....	62.8	.....	33.9	.....	25.0	.....	21.4
Raisin	Open	6	2.6	1	1.6	9	13.2	1	2.8	6	11.3	18	26.5	1	7.1
	Cover	6	2.6	6	9.7	2	2.9	4	11.4	14	26.4	13	19.1	2	14.3
	Barrow	14	6.1	4	6.4	4	5.9	3	8.6	4	7.5	2	2.9	1	7.1
Percentage (Raisin)		.....	11.3	.....	17.7	.....	22.0	.....	22.8	.....	45.2	.....	48.5	.....	28.5
Total catches		230	.....	62	.....	68	.....	35	.....	53	.....	68	.....	14	.....

TABLE 6. SUMMARY OF CATCHES AT MUD POND, MARCELLUS, 1933.

Entire catch included. Tabulated to show the combinations of bait and trap-set which were effective in catching each species.

BAIT	Trap-set	BLARINA		SOREX		PEROMYSCUS		ZAPUS		MICROTUS	
		Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.
Bacon	Open	5	2.5	3	1.5	10	9.6	2	3.2	.....	.....
	Cover	43	21.4	19	9.4	11	10.6	16	25.8	34	18.7
	Burrow	31	15.4	3	1.5	2	1.9	1	1.6	11	6.0
Percentage (Bacon)		.....	39.3	.....	12.4	.....	22.1	.....	30.6	.....	24.7
Peanut	Open	10	5.0	27	13.3	14	13.5	1	1.6	.....	.....
	Cover	79	39.3	144	70.9	18	17.3	15	24.2	37	20.3
	Burrow	18	9.0	5	2.5	6	5.8	1	1.6	15	8.2
Percentage (Peanut)		.....	53.3	.....	86.7	.....	36.6	.....	27.4	.....	28.5
Raisin	Open	.....	.....	.....	.....	16	15.4	1	1.6	.....	.....
	Cover	8	4.0	.....	.....	24	23.0	25	40.3	68	37.4
	Burrow	7	3.4	2	0.9	3	2.9	.....	.....	17	9.3
Percentage (Raisin)		.....	7.4	.....	0.9	.....	41.3	.....	41.9	.....	46.7
Total catches		201	.....	203	.....	104	.....	62	.....	182	.....

TABLE 7. SUMMARY OF CATCHES AT CONQUEST, 1934.

Entire catch included. Tabulated to show the combinations of bait and trap-set which were effective in catching each species.

BAIT	Trap-set	BLARINA		SOREX		PERO-MYSCUS		EVOTOMYS		ZAPUS		NAPAEO-ZAPUS		MICROTUS	
		Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.	Catch	Per cent.
Bacon	Open	2	3.3	9	10.6	15	11.5	7	2.9	4	6.1	.....	.....	2	2.7
	Cover	.....	.....	4	4.7	17	13.0	10	4.1	8	12.1	.....	.....	6	8.1
	Burrow	18	29.5	7	8.2	5	3.8	18	7.4	3	4.5	.....	.....	7	9.4
Percentage (Bacon)		.....	32.8	.....	23.5	.....	28.3	.....	14.4	.....	22.7	.....	.....	.....	20.2
Peanut	Open	.....	.....	14	16.5	25	19.0	55	22.7	5	7.6	3	.....	2	2.7
	Cover	8	13.1	20	23.5	24	18.3	41	16.9	20	30.3	1	.....	9	12.1
	Burrow	14	23.0	20	23.5	4	3.1	36	14.8	2	3.0	.....	.....	5	6.7
Percentage (Peanut)		.....	36.1	.....	63.5	.....	40.4	.....	54.4	.....	40.9	.....	.....	.....	21.5
Raisin	Open	.....	.....	4	4.7	22	16.8	18	7.4	5	7.6	1	.....	2	2.7
	Cover	7	11.5	3	3.5	14	10.7	29	12.0	19	28.8	1	.....	31	41.9
	Burrow	12	19.6	4	4.7	5	3.8	28	11.6	.....	.....	.....	.....	10	13.5
Percentage (Raisin)		.....	31.1	.....	12.9	.....	31.3	.....	31.0	.....	36.4	.....	.....	.....	58.1
Total catches		61	.....	85	.....	131	.....	242	.....	66	.....	6	.....	74	.....

TRAP-LINE STUDIES OF SMALL MAMMALS IN CENTRAL NEW YORK

BAIT PERCEPTION

As already noted, throughout our five seasons of field work records were kept of the baits used on each trap, and of the apparent effectiveness of each bait in attracting the various species. Early in the first season's work three types of bait were chosen and these were adhered to throughout the study. As discussed elsewhere, the traps were placed in the field in groups of three. One of these was baited with a small piece of bacon rind; the second, with half of a salted peanut; and the third with a seedless raisin. The baits were renewed each time the traps were taken in from the field, prior to resetting them in a new situation, and each day any baits which had been nibbled by insects or were otherwise found in bad condition were replaced with fresh. Traps were set close together with a view to trapping out the area.

In discussing the results from these three baits it is to be remembered that they represent materials foreign to the normal life of the animal. We might call them "foreign baits". A mouse or a shrew has never encountered a peanut, bit of bacon, or raisin, until it finds it on one of the traps. In rare instances it may be able to nibble and taste the bait, and then move on, but in general its first bite is its last. Consequently the animal has no chance to acquire a taste for a particular bait. Any "choice" that may be shown is due to its sense of smell, primarily, with a mere possibility that sight also is a factor.

Consequently, the fact that one species shows a "preference" for peanut bait is not in itself an important contribution to the ecology of the animal. Peanuts are not part of its normal environment. However, when we study a number of species comparatively we find that some show a decided tendency to be attracted by one bait, while others show no such tendency and are caught as frequently on one bait as on another. Thus Blarina showed a strong tendency to be caught on bacon and peanut baits, Sorex and Evotomys were caught mostly on peanut, and Napaeozapus mostly on raisin. On the other hand, Peromyscus, Zapus, and Microtus seem to be less definite in their reaction to the baits and through the several seasons appeared to take all three rather indiscriminately. Here there seems to be demonstrated a difference among species in their reactions to the three "foreign" baits, and this difference properly interpreted may be a matter of some importance. Presumably it is a question related to sense of smell, primarily, although other special senses may be involved to some extent; and the "curiosity" of the animal may, perhaps, also need to be considered.

In studying the relations of the animals to the various baits used, the aim was to present to the animal first of all a choice between the three baits; and accordingly the traps were set close together—as already noted. When an animal was caught, record was made of the bait as well as of the trap number.

At the end of each season's work, the trapping data were summarized in tabular form (tables 3, 4, 5, 6, 7). In these tables is shown what percentage of the catch was taken on bacon, on peanut and on raisin. The first part of Table 8 summarizes these percentage catches with reference to bait. In the use of such

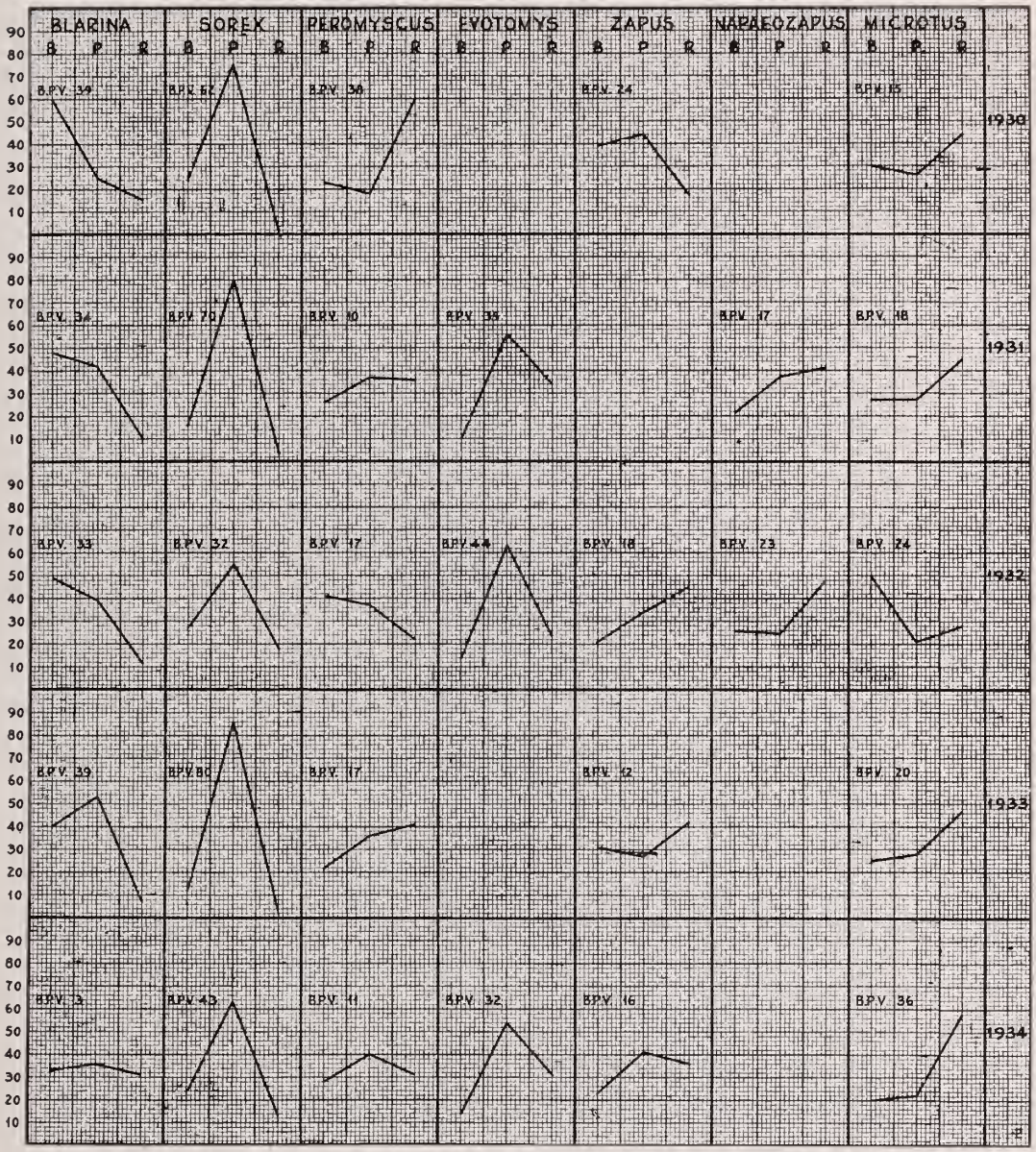


Plate 2. Bait ratios and bait perceptions. Percent of each species caught on bacon (B), peanut (P), and raisin (R). Data from Table 8. Bait perception value (B.P.V.) is given above each curve.

data we shall drop the unnecessary decimal fraction from the figures representing what is called for convenience the bait value. In Plate 2, the various bait perception values have been plotted to show ratios for the four successive seasons. In some cases the reactions of a species to the baits are consistent throughout the seasons, indicating a decided "species response". In other cases there is a difference in reaction in different seasons, which may perhaps be explained, in part at least, by the fact that not only the season but the locality was different.

Reactions to the individual baits are of interest, but there is another and more basic relation to be derived from the bait data, namely, the bait perception value above mentioned. This value is based on a scale of one hundred. It represents an attempt to measure the animal's tendency to discriminate, or to "choose", if it may be so called, among the three baits—or three odors—presented to it. Briefly, if an animal appears to "choose" one of the baits and entirely ignores the other two, or possibly avoids them, it would present a bait perception value of 100, the highest possible. On the other hand, if an animal is taken indiscriminately on all these baits and shows no "preference", it would show a bait perception value approaching zero, the lowest possible figure.

Mathematically the bait perception value is a sum of the deviations from 33⅓. Thus, if an animal is attracted to one bait to the exclusion of the other two, its index for that bait would be 100; while if it is attracted to all three baits indiscriminately, it would show for each an index of 33⅓. The extent to which the curve deviates from 33⅓ is considered a measure of the animal's "discrimination," or "perception" of difference among the three baits. Expressed in another way: Bait "perception" equals the sum of the deviations from 33⅓. In practice the fraction is ignored to avoid the appearance of meaningless accuracy.

An example will illustrate the method of calculating the bait perception value. Table 8 shows the values for the four seasons. Plate 2 shows the same data in another form and also records the derived bait perception value in each case. For example, Blarina in 1932 showed a "perception" value for bacon of 50, for peanut of 39, and for raisin of 11. The bait perception value is derived from this in the following manner:

$$\begin{aligned} 50 - 33 &= 17 \\ 39 - 33 &= 6 \\ 33 - 11 &= 22 \\ \text{Adding these,} - & \quad 45 \text{ is the sum deviation from 33.} \end{aligned}$$

As explained above, if all three baits furnished equal attraction the graph would be a straight line at 33. Hence the sum deviation just derived is a measure of the animal's tendency to choose among these baits. The more it "selects" one or two baits the more the curve will deviate from 33, for these baits.

As derived above, the highest figure would be that for an animal which was attracted to one bait only. Its "perception" value would then be

$$\begin{aligned} 100 - 33 &= 67 \\ 33 - 0 &= 33 \\ 33 - 0 &= 33 \end{aligned}$$

Sum is 133, the highest figure possible. This can be reduced to approximately

Fig. 5. Typical view of low woods near Mud Pond. Home of Evotomys, Peromyscus, *et al.* Conquest. Late June, 1934.

Fig. 6. A zone of typical meadow at Marcellus inhabited by Microtus, Blarina and Zapus. July, 1933.

Fig. 7. Weedy meadow along drainage ditch near Mud Pond (Conquest). Habitat of Zapus. Late June, 1934.

Fig. 8. Another weedy meadow habitat of Zapus. South of Mud Pond (Conquest). Late June, 1934.

100 by multiplying by .75. Accordingly all bait perception values are corrected to a scale of 100 by using this factor. The corrected values are recorded in Table 8 and Plate 2.

Bait "perceptions" of different species

Examination of the graphs and the bait perception values showed in some cases a remarkable similarity in successive seasons even though the localities were different.

Curves for Blarina were remarkably similar, showing chief attraction to bacon and peanuts in all seasons except 1934. The bait perception values also are similar, ranging from 33 to 39 during the first four seasons, then dropping to 3 in 1934, for some unknown reason, but perhaps correlated in some way with a much lower catch of this species in 1934.

Sorex showed a decided attraction toward peanut bait throughout the seasons, with an unusually high bait perception value in three out of five seasons. The data presented by the curves show rather conclusively that Sorex is attracted to the peanut bait more than to either of the other two baits used.

Peromyscus showed a variable reaction toward the baits. Perhaps, however, the curve for 1930 should be disregarded, since not more than 17 Peromyscus were taken that year, in contrast with the higher numbers in succeeding years. Examination of the data for other seasons shows that the members of this genus showed a variable reaction toward the three baits, but no decided leaning toward any one of them. The bait perception value for the four seasons was low, never exceeding 17.

The data of three seasons for Evotomys show considerable agreement, as indicated on the graphs. The animal seemed to be attracted for the most part to the peanut bait, the bait perception values varying from 32 to 44.

Results of four seasons for Zapus show varied reactions toward the baits. In 1932 at Constantia, and in 1933 at Marcellus, this animal showed a chief reaction toward raisin; but in 1930 at Brewerton and in 1934 at Conquest, toward peanut. The bait perception values for the four seasons varied from 12 to 24, and the catches of this form were fairly large (41, 53, 62 and 66). As mentioned elsewhere, the species is rather local in distribution.

Napaeozapus shows a similar disagreement between the curves for 1931 and 1932, but in each case it was attracted chiefly to raisin. Like Zapus, it has a rather low bait perception value (17 and 23), and likewise is a species that is local in its distribution. The catches for the two seasons were 51 and 68.

Data on Microtus show a chief attraction toward raisin in all but the 1932 season, when bacon had first place. Bait perception values for this form were always rather low, ranging from 15 to 36.

In general it seems evident that certain of the species concerned in this study show a definite reaction toward one or another of the three baits used,—a reaction which does not vary markedly in different localities and which seems to represent a characteristic reaction for the species. It would be of value to continue the study with other baits, selected perhaps with reference to their odors rather than to the types of food they represent.

Table 8. Summarizing Bait Ratios, Bait Perception Values, Place Ratios, and Place Perception Values for Each Species and Season.

SPECIES	Bait Ratios			Bait perception values	Place Ratios			Place perception values	Year
	Bacon, per cent.	Peanut, per cent.	Raisin, per cent.		Open, per cent.	Cover, per cent.	Burrow, per cent.		
Blarina	60	25	15	39	.....	.....	.....	.....	1930
	48	42	10	34	9	16	75	62	1931
	50	39	11	33	22	14	64	45	1932
	40	53	7	39	7	65	28	47	1933
	33	36	31	3	3	25	72	57	1934
Sorex	25	75	0	62	.....	.....	.....	.....	1930
	16	81	3	70	10	25	64	46	1931
	27	55	18	32	29	26	45	17	1932
	12	87	1	80	15	80	5	69	1933
	24	63	13	43	32	32	36	3	1934
Peromyscus	23	18	59	38	.....	.....	.....	.....	1930
	26	37	36	10	53	29	18	29	1931
	41	37	22	17	53	31	16	29	1932
	22	37	41	17	38	51	11	33	1933
	28	41	31	11	47	42	11	33	1934
Evotomys	10	56	34	35	34	32	34	2	1931
	14	63	23	44	37	34	29	6	1932
	14	55	31	32	33	33	34	1	1934
Zapus	39	44	17	24	.....	.....	.....	.....	1930
	21	34	45	18	27	62	11	42	1932
	31	27	42	12	6	90	3	85	1933
	23	41	36	16	21	71	8	56	1934
Napaeozapus	22	37	41	17	57	35	8	38	1931
	26	25	49	23	53	37	10	35	1932
Microtus	30	26	44	15	.....	.....	.....	.....	1930
	27	27	46	18	27	64	9	45	1931
	50	21	29	24	14	57	29	35	1932
	25	28	47	20	0	76	24	63	1933
	20	22	58	36	8	62	30	43	1934

PLACE PERCEPTION

It is to be recalled that the traps were set in groups of three, in lines through the areal unit selected. The groups were spaced about three feet from each other, and the lines continued in a straight course. There was thus obtained a random sample of the habitat in all its phases. During the last four seasons of field work it was decided to keep a record not only of the kind of bait with which each individual specimen was caught, but also of the spot where the trap was set. The spots or "places" were divided into three categories: (1) "open", or a spot where the trap was not in contact with anything except the ground, being surrounded by a small open space about two feet or more in diameter; (2) "cover", or a spot in which a bunch of grass, a pile of loose brush, or a log would tend to hide the trap from above; (3) "burrow", where the trap was either set in the

mouth of a burrow apparently made by some small mammal, or else was set within such a burrow after enlarging it sufficiently for that purpose.

These three types of sets were chosen with the thought that some of the mammals concerned might show a tendency to stay in burrows much of the time, when there would be more or less constant contact with the surrounding soil; others might venture out in a place where grass or brush would hide them from attacks from above; and still others might perhaps venture into the open spots

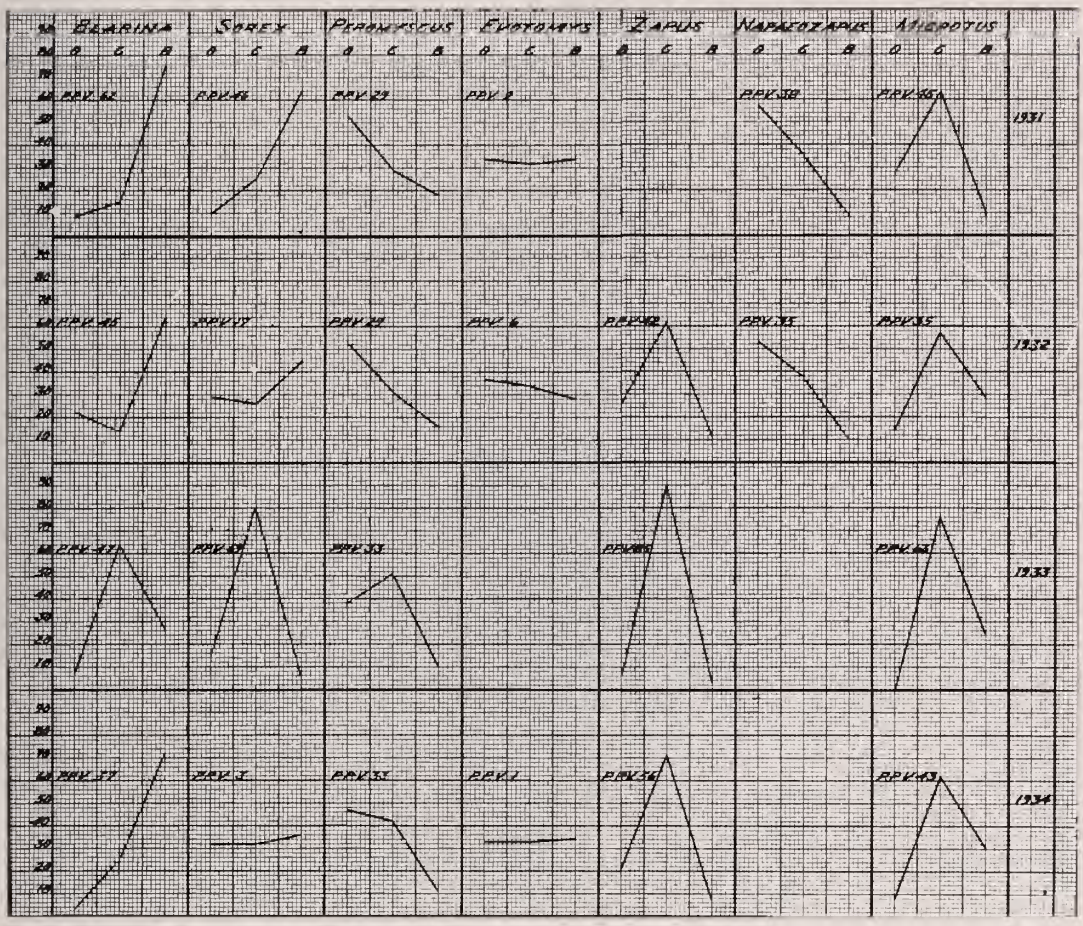


Plate 3. Place ratios and place perceptions. Percent of each species caught in open places (O), cover places (C), and burrows (B) are plotted. Data from Table 8. Place perception value (P.P.V.) is given above each curve.

in their habitat, crossing these small "clearings" and generally moving about freely, and perhaps even avoiding burrows. The data served to show that such different tendencies among the species do exist. Each species apparently responds in its own way to the small "places" within its habitat.

Tables 4 to 7 present the data for the seasons during which *placing* of the traps was given careful attention. From these tables the total percentages of a species caught in open, in cover, or in burrow can readily be derived, and these percentages are reassembled in the second half of Table 8.

Treating these figures in the same way as was done for the study of baits, we may call each figure a "place value". Thus for Blarina, in 1931, 9.3% were caught in the open. This becomes a place value of 9. For Blarina, 15.6% caught in cover gives a place value of 16 (nearest whole number), etc. In Table 8, these place values have been assembled to represent a "place ratio", or in other words an "open-cover-burrow" ratio. The same thing has been further represented in Plate 3, where a curve is derived for each species each season to represent its reaction to the "places". Study of the graphs on this plate shows that some of these mammals apparently have a decided tendency to enter one or another of the three "places" under discussion, while others seem to show no such definite tendency, but wander about at random in their habitats. Thus it would appear that some small mammals show a higher sensitivity toward the minor features of their surroundings than do others. This thought has suggested the attempt to derive a "place perception" value for each species, as a measure in mathematical terms of its degree of reaction toward certain of its immediate surroundings.

The method of deriving the place perception value is similar to that used for obtaining the bait perception value. If an animal shows no particular, definite or consistent responses to its immediate surroundings, its place values when plotted on a curve (as in Plate 3) would make a straight line at the 33 (mean) level. The more the parts of the curve deviate from this mean value, the more consistent is the animal's response to the "places". Thus, the value is a sum of the deviation from 33.

Using Blarina (for 1931) as an example, the calculation is as follows:

$$33 - 9 = 24$$
$$33 - 16 = 17$$
$$75 - 33 = 42$$

Sum equals 83. This is corrected to a scale of 100 by multiplying by .75, giving the final place perception value for Blarina at 62, on a scale where 100 would be the highest possible figure.

Place perception values as presented on Plate 3 and Table 8

Blarina showed, during the seasons 1931, 1932 and 1934, a decided "preference" for the burrows, presenting as high a perception value as 62 in 1931. The animal did at times leave the burrows and was caught in "open" and "cover", but it was much more likely to be found in the "burrow". In 1933 a preponderance of thick "cover" in the habitats studied apparently was responsible for its frequent occurrence here.

Sorex showed a high frequency in burrow "places" in 1931, a lesser one in 1932, a greater frequency in cover in 1933, and almost no apparent discrimination in 1934.

Peromyscus for three seasons was taken most frequently in "open" spots in its habitat. The curves for the first two seasons are remarkably similar, and the place perception value is 29 in each case. In 1934 the reaction was much the same; but in 1933 a different area yielded a good catch in "cover".

Evotomys, during the three summers that this species was included, seemed to show no definite response to "places" in its habitat. In all cases the curve is almost a straight line, and the place perception value is very low, namely, 2, 6, and 1. This indicates that the animal wanders into burrows, under cover and into the open equally freely and is found in one of these places as often as in another. The data for 1934 seem to leave but little doubt of the accuracy of this conclusion.

Zapus showed a strong tendency toward "cover", during three seasons, place perception being rather high,—42, 56, and 85. This may appear a bit surprising in view of the jumping habit of the species, but probably it does not as a rule progress by leaps when moving about undisturbed in its home territory.

Napaeozapus for two seasons showed a remarkably consistent tendency to be found in the "open" spots in its habitat. Thus while the animal is a woodland form, primarily, it nevertheless frequents mainly open spots within this woods habitat, and perhaps thereby it avoids contact with certain other species. The species is spoken of in the literature as being rare, but perhaps if traps were more frequently set in open places, more specimens would be taken.

Microtus, like Zapus, was most frequently taken in "cover" and it has the rather high place perception value of 35 to 63.

In general the various species studied show more correlation with regard to place perception in succeeding seasons, in similar localities ('31 and '32), than they do with regard to bait perception, and the results indicate a definite attraction toward the local "places" in most cases. While several species may live in the same habitat, each tends to occupy its own niche within that habitat, and by so doing may possibly avoid, to a considerable extent, the other species.

WANDERING TENDENCY VALUE

The areas in which wandering tendency was studied were rather limited in extent, although during the preliminary examination of areas an effort was made to choose such as contained a larger sample of a certain type of habitat, conforming with the known habitats of the forms to be studied. For example, for species such as Napaeozapus, Peromyscus and Evotomys, typical woods habitat was required, while for Zapus and Microtus, wet meadow was needed. Such a form as Blarina is here found practically wherever these other small mammals occur.

Migrations of animals have been studied by a number of authors. Many kinds of animals migrate to some extent, the movements varying in character. Shull, in his "Principles of Animal Biology", has classified migrations under three headings, which seem significant. Periodic migrations are defined as movements in large numbers from one place to another at different times of the year, or at different times in their life history. Migrations of birds and of fresh-water eels are good examples of this periodic migration. Among mammals we might mention the migrations of elk and mule deer in Yellowstone Park, where the animals make a seasonal migration to and from the higher altitudes (Skinner, '25; Russell, '25, '31; Weydemeyer, '28); also such migrations as those of the seals moving to and from their breeding grounds, or the periodic movements of certain whales to and from the south seas, following the changing food supply

(Beddard's Book of Whales). (Heape, '31, quoting Jenkins, '21). Anthony ('23) mentions the chief hare, muskrat, yellow-bellied woodchuck, and bushy-tailed woodrat as showing periodic migrations. Heape ('31, pp. 215–229) names several mammals which show periodic migrations, among them hippopotamuses, elephants, mule deer, caribou, wild asses, seals and bats. Among the small mammals studied during this investigation no examples of periodic migrations were noted, although it is possible that such might be found if the study were to be carried on throughout the entire year.

Shull's second type of migration is the sporadic migration which refers to the sudden outbreaks or eruptions of a species from its home locality. The stock example is the occasional migration of hordes of lemmings from the tundra of the north of Lapland, which results in a direct movement of thousands of these mammals westward across the country to perish finally in the sea. Heape ('31, p. 107) describes in detail sporadic migrations of the spring-buck in Africa. Among other things, he says:—"Besides being nomadic in habit for the greater part of the year, even following the track of the thunderstorms as the Boers do; besides migrating annually to a more fertile region for the calving season; perhaps once in every 10 or 20 years they emigrate in vast numbers. From this migration, none return, and, like the lemming, they emigrate westward." Heape (*loc. cit.*) ascribes such cases of sporadic migration to increased vitamin content of the food supply, leading to rapid growth and reproduction.

A third type of migration is designated as normal migration. According to Shull, "This is best seen in free-moving terrestrial forms. Among the individuals of such forms there is constant movement; and either as individuals or as flocks they wander about over a larger or smaller area, according to their powers of locomotion, to seek food, escape enemies, or find mates."

No evidence of sporadic or periodic migrations was noted in the course of the present field work. The type of migration with which we are concerned in this study is that which is designated as normal, but it seems preferable to consider it a wandering rather than a migration. Therefore an attempt was made to develop a method of analysis of this wandering tendency, which resulted in what is herein called the "wandering tendency value", or simply the "wandering value".

Small mammals do not always stay "at home". From time to time, or perhaps continually, they may move into new territory near by. This tendency is here called the "wandering tendency". At times it may, possibly, assume the proportions and directions of a migration, but as will be shown later, there is some evidence to suggest that a true migration such as shown by the lemmings of the north is probably something else,—not merely an exaggeration of the normal wandering tendency, but a different phenomenon.

In studying the wandering tendency, a numerical method has here been devised for expressing this tendency on a scale of 0 to 100 and over. Careful study indicates that the wandering tendency is not a simple thing, but a complex of several elements in the animal's habit and behavior, any one or more of which may cause variations in the results in a given case. These elements may best be discussed after describing the method of derivation of the wandering tendency value and pointing out some of the results. In general, an animal which is not inclined to wander and which does not readily invade new or trapped-out territory,

Fig. 9. Weed meadow. Conquest. July, 1934.

Fig. 10. Meadow near outlet of North Constantia reservoir. Habitat of Zapus, Blarina and Microtus. August 8, 1932.

Fig. 11. Trap set in burrow mouth. St. Mary's Pond. 1931.

Fig. 12. Typical live-trap set in Lincoln's woods. Conquest. August 1, 1934.

has a low wandering tendency; an animal which boldly enters new territory at a steady rate and passes on through, as the lemmings are reported to do in their migrations, would have a wandering tendency value of 100. And an animal which is entering a territory at a steadily increasing rate, and staying there—in other words showing a tendency to concentrate there,—would show a wandering tendency value of over 100.

Accordingly, the method used in deriving the wandering tendency value was as follows: Traps were handled in the field in units of 198. Half of these traps were operated as a "moving quadrat" through the area selected. That is, the traps were kept in place for three days, and were then moved to a new location for another three days, as described in an earlier section of this paper. The catch in this type of trapping was presumably the "home animals", and it was assumed that in three days the animals present on the given area were all caught.

Near this moving quadrat, and in the same type of territory, were placed the remaining 99 traps in a straight line, referred to as the "stationary line". The first three-day catch on this line also, it was assumed, represented "home animals", and was added to the catch obtained on the "moving quadrat". After the three-day period the stationary line usually still continued to catch a few specimens, and these we assumed were the "wandering individuals" which had just entered the area from surrounding territory. They were in a sense invaders. The entire unit of traps—moving quadrat and stationary line—was thus kept in operation for 14 days, then was moved to some new location.

Briefly, the wandering tendency value is derived by dividing the number of wandering individuals by the number of home individuals and adjusting the results to a scale where 100 is the theoretical value for the case of a migration through the territory at a uniform rate. The adjustment to a scale of 100 is important and will be discussed later. It furnishes a means of interpreting results in event that some other than the 14-day period should be used. The studies can be put on a common ground by adjusting to the same scale, based on a theoretical, steady wandering movement.

Table 9 gives the data from all the trap units which lent themselves to this kind of analysis. In each case a moving quadrat (M. Q.) operating 14 days is matched by a stationary line (S. L.) also operating 14 days in the same type of habitat for the same period. Column 1 gives the numbers of moving quadrats or stationary lines employed, and column 2 designates the habitat; then follow the catches for each species, listed according to sex.

Table 10 reassembles the catch results, giving total three-day catches and total late catches (after three days) for each sex. The wandering tendency value and the method of deriving it are briefly as follows:

Taking Blarina females in 1931 as an example, there were 5 wandering individuals caught, and 15 "home animals", giving a ratio of 5:15, or 33⅓ in terms of percentage. This figure must next be adjusted to a scale of 0 to 100 and over, by use of a factor obtained by studying a theoretical case of a steady "migration" or movement through the area trapped. The reasoning is as follows:

Let X equal the number of individuals per day entering a unit area in a steady movement (where none of the animals stays permanently in the area, and the invasion takes place at a steady or uniform rate).

There are three short lines (33 traps in each) making up the stationary line. The socalled wanderers would continue to be caught for 11 days after the initial three-day period on this line. Then, 3 times 11X equals 33X, the number of wanderers caught during the trapping period.

Similarly for the three-day catch we can assume that during the 14-day period there were in operation in the moving quadrat the equivalent of 14 short lines catching the animals for three days. Fourteen times 3X equals 42X, the number of animals caught on the moving quadrat in 3-day periods. Add to this 9X (3 times 3X) animals caught on the stationary line for its first three days, and we have a total of 51X individuals, the "home animals" caught, or the "early" catch (E). The "wanderers" or "late" catch are represented by (L).

Deriving the hypothetical wandering tendency value for this movement, we find that 33X divided by 51X gives a percentage value of .647 for a theoretical steady wandering. This can be reduced to a scale of 0 to 100 and over, by use of a factor: 100 divided by .647 equals 154.5, the factor.

In practice this adjustment is made by use of the formula W. T. V. equals 154.5L/E. Thus, in the example given above for Blarina females in 1931, W. T. V. equals 154.5 times 5/15, or 51. Thus the wandering tendency values in Table 10 were derived as indicated. The data for four seasons, 1931, 1932, 1933 and 1934 are given in order.*

Discussion of the Wandering Tendency Data

The wandering tendency value of a species of animal is the result of a complex of factors, any one of which may be the dominant one for any particular species, or in any given season. First of all an animal may, perhaps, wander about and shift its home locality in the course of its search for food. This doubtless is frequently of paramount importance, and the extent of the wandering due to this factor varies, probably, with the abundance of the food. For example, carnivores like the weasel and the mink wander over a wide range, stopping perhaps here and there in localities where mice and birds are abundant. As soon as the local supply is exhausted, they move on again. They have a high wandering tendency,—a tendency to invade any area where food is abundant. This may explain in part, perhaps, the tendency for carnivores to show a peak of abundance correlated with the peak of small rodent abundance. Again, the shrews and the moles, feeding largely on insects, earthworms etc., and characterized by a high rate of metabolism, would probably have to shift their feeding grounds continually in order to satisfy their demands.

Besides the search for food, instinct for contact with their own kind, or the social instinct, no doubt plays a part at times in connection with the wandering tendency. And particularly during the breeding season the search for a mate, fighting among rivals, and other activities connected with this season, all may become important factors in the movements of animals in and out of the various parts of the home area or range. The arrival of the young is an event that

* While the 14-day period used in this study has advantages, it is felt that future work should be planned on the basis of a 12-day trapping period. This would lead to a much simpler calculation, using a 3-day period as a unit. The theoretical ratio would then be 3X divided by 5X instead of 33X divided by 51X, etc.

may modify the behavior profoundly. It may lead to the driving away of the males to wander in some other area, for the time being, at least; and as regards the female, the presence of young in the nest may cause all her wanderings to center more closely about its location and perhaps may intensify her activity in a limited area as the need of food for herself and young increases.

The wandering tendency value as defined in this paper differs somewhat for different species. This may be due to the fact that one species customarily wanders through a larger home range than does another, or that it wanders throughout the extent of this range faster or more slowly than does another species. Reactions toward other individuals of the same or of different species or sex may have their effect. While one species or sex may be unaffected by the presence of another, living its own life independently of the animals around it, another may be forced to leave its old home territory by pressure from another species,—either by direct aggression or by competition for food and shelter. If a species "respects" the "territorial rights" of another, this will affect the wandering tendency as shown by the data. Such a species might be caught more frequently in the later trap days, after the original "owner" of the territory had been trapped out. The wandering tendency value is to some extent a measure of the "reinvasion tendency" of the animals studied, the tendency to reinvade a trapped-out area being the main principle concerned.

The natural aggressiveness or "pioneering tendency" of the species is an important element. One species might stay where it was, for a time, even though favorable territory had just been opened up near by, while another species under similar circumstances might quickly push into the new area as soon as its original occupants had been removed.

Seasonal changes in the environment probably have an important effect in some cases. Zapus, for example, frequently showed a high wandering tendency, due perhaps to the fact that the meadows were drying up during the summer, and the animals consequently tended to concentrate more and more in the moister parts. Wandering tendency values of more than 100 are on theoretical grounds due to a concentration tendency of this sort.

The studies seem to indicate that one of the most important modifying factors in the wandering tendency is that of sex, and therefore all studies of this sort, it would seem, should be made with due regard to this factor. A glance at tables 10 and 11 indicates that the wanderings of the males usually differ in extent from those of the females, in all the species here concerned.

SEX RATIOS AND THE WANDERING TENDENCY

Table 12 lists the catches for several species, arranged to show the sex ratios as found in various habitats and seasons. The totals at the bottom of the table show that there was a preponderance of males in the catches of all species. In Table 13 the data are expressed in percentages of males, by habitats, and show some interesting relations. We note that the percentage of males varies in many cases with reference to the habitat where the animals were taken. Thus, in Blarina the males appear to be more numerous in the dry woods, while the females appear usually to be more numerous in the moist woods. In the meadow the sexes are

more evenly divided. Sorex shows a slightly higher percentage of males in the meadow than elsewhere. Peromyscus shows a high percentage of males in all habitats, the figure being above 50 in all cases for this species. Evotomys, too, shows a high percentage of males (66 to 91) in all instances. Zapus shows a sex ratio varying with the seasons, and the reason is not clear. Napaeozapus varies likewise, and Microtus again shows a high percentage of males wherever a considerable number of individuals is represented.

Thus it appears that in compiling sex ratios from trapping results it is necessary to give proper consideration to the habitats where the animals are taken—a point perhaps too often ignored in field studies.

Table 14 summarizes all the available data on sex ratios without reference to the habitats, emphasizing again the high percentage of males in Peromyscus, Evotomys, and Microtus.

In seeking a reason for the higher percentage of males in many of the catches, the study of the wandering tendency appears to be of considerable interest. Referring to Table 10, again, we note that for each season the actual catches of males and females are given, followed by the ratio which is the basis for the lowermost item in each case, namely, the wandering tendency value (W. T. V.). Arrows point in each case from the lower to the higher figure of any pair. A study of these figures discloses the fact that in many cases the higher percentage of males is correlated with the higher wandering tendency of this sex. In Peromyscus, for example, males predominate in the catches. Their wandering tendency is always higher than that of the females, and presumably that is why they tend to be caught more often in the traps. The same correlation is to be noted from the same table (10) in the case of Evotomys and Microtus. Zapus shows the same thing, except in the 1932 study when higher catches of females were apparently correlated with a higher wandering tendency of females. Blarina, Sorex and Napaeozapus show the same relation in some seasons, but not all. Accordingly we may perhaps state as a tentative conclusion that a higher wandering tendency in one of the sexes leads to a higher catch of that sex. In Table 10, 15 out of 20 instances support this conclusion. Evidently random trapping in a habitat does not give a true idea of the sex ratio of the animals present; the different wandering tendencies of the two sexes must be taken into consideration as well as the habitat.

In Table 11 the available data are reassembled to show sex ratios and wandering tendencies based on habitats. From this table it is to be noted that Peromyscus, Evotomys and Microtus still show a high catch of males, doubtless explainable on the basis of a higher wandering tendency of this sex. Zapus shows a lack of correlation due to the fact that, as noted above, in one season the females apparently were the chief wanderers and furnished the highest catch. Sorex shows a correlation of high catch and high wandering tendency for the males, in the weed-meadow and the cedar-meadow habitats. Blarina and Napaeozapus do not show a similar correlation. This table, of course, is made up on the assumption that dry woods, for example, constitutes the same type of habitat in each of the seasons of study and in different localities. While this is approximately correct, yet there is no doubt a good chance for error in considering some habitats as "the same" from season to season.

TABLE 9. SUMMARIZING VARIOUS SEASONS' CATCHES BY HABITATS.

Catches on Moving Quadrats (M.Q.) and Stationary Lines (S.L.) are tabulated for each season and habitat.

TRAP UNITS	Habitat	BLARINA			SOREX			PEROMYSCUS			EVOTOMYS			ZAPUS			NAPAEOZAPUS			MICROTUS		
		F.	M.	?	F.	M.	?	F.	M.	?	F.	M.	?	F.	M.	?	F.	M.	?	F.	M.	?
1931																						
3 M.Q.	Dry woods	5	4		3	0		7	12	2	0	2					2	2				
3 M.Q.	Moist woods	8	3		6	0	1	5	13		1	6					6	3	1			
(3 days)																						
3 S.L.	Dry woods	2	2		4	0		1	0		3	3					0	0				
3 S.L.	Moist woods	0	5		2	2		0	1		0	4					1	5	1			
(Later)																						
3 S.L.	Dry woods	1	7		1	0		2	7		0	1					0	0				
3 S.L.	Moist woods	4	2		5	0	2	0	2		0	1					6	2				
1932																						
3 M.Q.	Dry woods	6	16		3	3	1	3	4		2	4					2	3				
8 M.Q.	Moist woods	33	24		10	10	1	6	14		4	12					4	15	1			
5 M.Q.	Meadow	9	10		1	1		0	0		0	0		8	8	1	1	3		0	6	
(3 days)																						
3 S.L.	Dry woods	2	3		1	0		2	3		0	0					0	2				
8 S.L.	Moist woods	6	11		1	3	1	3	1		1	3		0	1		4	5				
5 S.L.	Meadow	3	3		0	0		0	0		0	0		3	4		1	1				
(Later)																						
3 S.L.	Dry woods	5	5		1	1		2	6		0	1					1	0				
8 S.L.	Moist woods	9	7		6	7	1	3	4		0	1		2	0		4	4	2			
5 S.L.	Meadow	4	3		0	1		0	0		0	0		11	3		0	3	1			
1933																						
2 M.Q.	Dry woods	2	10		0	0		2	8					0	0							
2 M.Q.	Moist woods	3	6		3	8		5	6					0	1					1	0	
4 M.Q.	Meadow	8	17		5	10		0	0					2	8	1				16	34	1
5 M.Q.	Cedar-meadow	4	10		24	23		4	10					1	1					11	10	
2 M.Q.	Woods-meadow	5	4		2	8		2	5					5	6					1	1	
1 M.Q.	Dogwood	4	4		4	2		3	4					1	1					0	2	
2 M.Q.	Sweet flag	0	1		1	5		0	0					3	0					8	8	1
(3 days)																						
2 S.L.	Dry woods	0	0		0	0		1	3					0	0					0	0	
2 S.L.	Moist woods	1	6		1	1		1	2					0	0					0	1	
4 S.L.	Meadow	2	2	2	0	0		1	0					0	0					3	5	
5 S.L.	Cedar-meadow	5	11		4	6		1	2					0	0	1				4	11	
2 S.L.	Woods-meadow	1	0		0	1		0	0					1	1					1	4	
1 S.L.	Dogwood	0	0		0	0		0	0					0	1					0	0	
2 S.L.	Sweet flag	1	0		2	0		0	0					0	1					3	4	
(Later)																						
2 S.L.	Dry woods	2	7		0	0		1	3					0	0					0	0	
2 S.L.	Moist woods	2	2		5	9		4	3	1				0	0					0	0	
4 S.L.	Meadow	9	12	1	1	5		0	6					5	7					4	14	
5 S.L.	Cedar-meadow	8	11		12	24		2	2					3	2					6	10	
2 S.L.	Woods-meadow	10	2		4	8		0	0					0	4					2	1	
1 S.L.	Dogwood	1	1	3	4	3	1	0	1					0	0					4	3	
2 S.L.	Sweet flag	4	3		4	2		0	0					1	2	1				2	7	
1934																						
2 M.Q.	Dry woods	2	1	1	0	0		4	7													
12 M.Q.	Moist woods	7	2		8	18	4	20	36	2	43	74	4	4	2		0	4		0	1	
5 M.Q.	Meadow	4	2	1	0	0		0	0					6	16	1				11	14	1
4 M.Q.	Marsh	0	3		3	3		0	0					0	3					3	13	2
(3 days)																						
2 S.L.	Dry woods	0	3		0	0		0	2													
12 S.L.	Moist woods	1	3		2	5		9	12	1	10	20	1	0	1							
5 S.L.	Meadow	2	3		0	0		0	0					3	2	1				1	6	3
4 S.L.	Marsh	0	0		0	2		0	1					1	2					4	3	
(Later)																						
2 S.L.	Dry woods	5	2		0	0		1	5													
12 S.L.	Moist woods	4	2		12	11	6	2	9	2	17	41	7				0	1		1	0	
5 S.L.	Meadow	3	5		2	2		0	0					12	20	19				2	2	
4 S.L.	Marsh	0	0		1	2		0	0					2	2							

NOTE.— Specimens which were not sexed are listed in the columns headed with a " ? " mark.

TABLE 10. SHOWING DERIVATION OF THE WANDERING TENDENCY VALUE (W. T. V.) FROM DATA IN TABLE 9, AND THE CORRELATION OF THIS VALUE WITH THE SEX RATIOS IN EACH CASE.

	Blarina		Sorex		Peromyscus		Evotomys		Zapus		Napaeozapus		Microtus	
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M	F.	M.	F.	M
1931														
Catch	20→23		21←3		15→35		4→17				15←12			
L/E	5/15	9/14	6/15	2/1	2/13	9/26	0/4	2/15			6/9	2/10		
W. T. V.	51→99		62		23→52			20			102←31			
1932														
Catch	77→82		23→26		19→32		7→ 21		24←16		17→36			
L/E	18/58	15/67	7/16	9/17	5/14	10/22	0/7	2/19	13/11	3/13	5/12	7/29		
W. T. V.	48←35		67→82		55→70			16	182←35		64←37			
1933														
Catch	72→109		76→117		27→55				22→35				66→115	
L/E	36/36	38/71	30/46	51/66	7/20	15/40			9/13	15/20			18/48	35/80
W. T. V.	154←82		100→119		54→58				107→116				57→67	
1934														
Catch	28←26		28→43		36→72		70→135		17→46		5		22→39	
L/E	12/16	9/17	15/13	15/28	3/33	14/58	17/53	41/94	3/14	20/26			3/19	2/37
W. T. V.	116← 81		178←82		14→37		49→67		32→119				24→83	

Formula:
W. T. V.= 154.5 L/E

Abbreviations and symbols:
E — Early catch
L — Late catch
154.5 — Factor derived for the particular trapping method described in the text.
Arrows point from lower to higher numbers in the sex ratios.

TABLE 11. SHOWING RELATION OF WANDERING TENDENCY VALUE TO HABITATS.

For each habitat and species the catch is given the ratio L/E, and finally the W. T. V. in cases where the catch was fairly large.

	Blarina		Sorex		Peromyscus		Evotomys		Zapus		Napaeozapus		Microtus	
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
DRY WOODS														
Catch	32→60		13←5		26→60		5→11				5	7		
L/E	13/19	21/19	2/11	1/4	6/20	21/39	0/5	2/9			1/4	0/7		
MOIST WOODS														
Catch	78←73		61→74		58→103		76→162				25→39			
L/E	19/59	13/60	28/33	27/47	9/49	18/85	17/59	43/119			10/15	7/32		
W. T. V.	49←33		131←88		28→32		44→56				102←31			
MEADOW														
Catch	44→57		9→19		1	6			50→68		2	7	37→81	
L/E	16/28	20/37	3/6	8/11					22/28	30/38			6/31	16/65
W. T. V.	88←83		77→112						121—121				29→38	
CEDAR-MEADOW														
Catch	17→32		40→53		7→14				4	3			21→31	
L/E	8/9	11/21	12/28	24/29	2/5	2/12							6/15	10/21
W. T. V.	137←80		66→128		61←26								61→73	
WOODS-MEADOW														
L/E	10/6	2/4	4/2	8/9	0/2	0/5			0/6	4/7			2/2	1/5
DOGWOOD														
L/E	1/4	1/4	4/4	3/2	0/3	1/4			0/1	0/2			4/0	3/2
SWEET FLAG														
L/E	4/1	3/1	4/3	2/7					1/3	2/1			2/11→7/12	
W. T. V.													28→90	
MARSH														
L/E	0	0/3	1/3	2/5					2/1	2/5			2/7←2/16	
W. T. V.													44←19	

TABLE 12. TOTAL CATCHES BY SEXES FOR FOUR SEASONS — ASSEMBLED ON BASIS OF HABITAT. From Table 9, early and late catches combined.

	BLARINA		SOREX		PEROMYSCUS		EVOTOMYS		ZAPUS		NAPAEOZAPUS		MICROTUS	
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males
1931														
Dry woods	8	13	8	1	10	19	3	6	0	0	2	2	0	0
Moist woods	12	10	13	2	5	16	1	11	0	0	13	10	0	0
1932														
Dry woods	13	24	5	4	7	13	2	5	0	0	3	5	0	0
Moist woods	48	42	17	20	12	19	5	16	2	1	12	24	0	0
Meadow	16	16	1	2	0	0	0	0	22	15	2	7	0	6
1933														
Dry woods	4	17	0	0	4	14	0	0	0	0	0	0	0	0
Moist woods	6	14	9	18	10	11	0	0	0	1	0	0	1	1
Meadow	19	31	6	15	1	6	0	0	7	15	0	0	23	53
Cedar-meadow	17	32	40	53	7	14	0	0	4	3	0	0	21	31
Woods-meadow	16	6	6	17	2	5	0	0	6	11	0	0	4	6
Dogwood	5	5	8	5	3	5	0	0	1	2	0	0	4	5
Sweet flag	5	4	7	9	0	0	0	0	4	3	0	0	13	19
1934														
Dry woods	7	6	0	0	5	14	0	0	0	0	0	0	0	0
Moist woods	13	7	22	34	31	57	70	135	4	3	0	5	1	1
Meadow	9	10	2	2	0	0	0	0	11	38	0	0	14	22
Marsh	0	3	4	7	0	1	0	0	3	7	0	0	7	16
Totals	198	240	148	189	97	194	81	173	64	99	32	53	88	160

TABLE 13. SEX RATIOS: FIGURES REPRESENT PERCENTAGE OF MALES BASED ON TOTAL CATCHES.

Data from Table 12, thus including the three-day catch and the late catch combined. Arranged by habitats and seasons.

	Blarina	Sorex	Peromyscus	Evotomys	Zapus	Napaeozapus	Microtus	Year
Dry woods	62	11	65	66	.....	50	.....	1931
	65	44	65	71	.....	62	.....	1932
	81	.....	78	.....	.....	.....	.....	1933
	56	.....	74	.....	.....	.....	.....	1934
Moist woods	45	13	76	91	.....	43	.....	1931
	41	54	51	76	33	67	.....	1932
	70	67	52	.....	100	.....	.....	1933
	35	61	65	66	.....	.....	.....	1934
Meadow	50	66	.....	.....	41	78	.....	1932
	62	71	81	.....	68	.....	70	1933
	53	61	.....	.....	74	.....	69	1934
Cedar-meadow	65	57	67	.....	43	.....	59	1933
Woods-meadow	27	74	71	.....	65	.....	60	1933
Sweet flag	44	56	.....	.....	43	.....	59	1933
Marsh	100	63	100	.....	70	.....	70	1934
Dogwood	50	38	62	.....	67	.....	55	1933

Fig. 13. View of mixed woods-meadow at Marcellus. Habitat of Microtus, Blarina, Sorex, Zapus and an occasional Peromyscus. August 7, 1933. Photograph by John Pearce.

Fig. 14. Sedge meadow near Little Bay Creek, north of Brewerton. Habitat of Zapus, Microtus and Blarina. August 22, 1930.

Fig. 15. The alder zone along shore of St. Mary's Pond. Grassy bog in foreground is flooded in certain seasons and shows almost no mouse population.

Fig. 16. Sedge and cat-tail marsh south of Mud Pond, near Conquest. Late June, 1934.

TABLE 14. SUMMARY OF SEX RATIOS FOR FIVE SEASONS, WITHOUT REFERENCE TO HABITATS, AND INCLUDING SOME INDIVIDUALS NOT CAUGHT ON THE REGULAR QUADRATS.

Percentage of males shown at bottom.

	Blarina	Sorex	Peromyscus	Evotomys	Zapus	Napaeozapus	Microtus
1930							
Males	46	9	11	.....	26	.....	18
Females	66	10	5	.....	15	.....	5
1931							
Males	63	13	76	31	2	18	9
Females	56	49	46	8	4	30	4
1932							
Males	99	28	53	27	25	44	13
Females	115	30	23	8	27	20	1
1933							
Males	111	122	61	.....	36	.....	115
Females	74	77	35	.....	23	.....	68
1934							
Males	27	43	77	134	48	6	40
Females	33	28	41	71	15	.....	24
Percentage of males							
1930	41	47	69	.....	63	.....	78
1931	53	21	62	79	33	37	69
1932	46	48	70	77	48	69	93
1933	60	61	63	.....	61	.....	63
1934	45	60	65	65	76	100	62

HABITAT AND COMMUNITY STUDIES

Throughout the studies in the field it was noticeable that Blarina was caught in nearly every type of habitat selected, while other species were more restricted in their distribution. This fact suggested a study of the data with a view to expressing mathematically the degree of response or "perception" which each species might show with reference to its habitat. In this connection the term "habitat" refers to a larger area than did the term "place" in an earlier connection.

Accordingly, using the data for three seasons, the habitats were classified into three major groups, namely, (1) dry woods, along the ridge tops; (2) the moist woods in the hollows between the ridges and along streams and shores; and (3) the meadow. All the present studies in the field centered around these three general types of habitat,—excepting a few special habitats encountered at Marcellus and at Conquest. In assembling the data under the three headings given, the records of those catches that were made during the first three trap-days in each case have been used, since later catches present a different problem, involving the "wandering" individuals.

During the summer of 1930, at Brewerton, the trapping was confined almost entirely to moist woods and wet meadows; in 1931, at St. Mary's Pond, it was confined to dry woods and moist woods. The only "meadow" available here was the quaking bog which yielded almost nothing in the test traps and therefore was

not given much further attention. In the 1932 and 1934 seasons, data were obtained from all three classes of habitat mentioned; and the same was true for 1933, at Marcellus. The 1934 study at Conquest included also a sedge marsh habitat in addition to the three main types. The 1933 season at Marcellus included additional study in sweet flag, dogwood, and cedar-meadow habitats.

Population per Acre

In population estimates the actual catch in all traps for a three-day period was multiplied by a factor according to the number of trap lines used. Each short line of thirty-three traps, as noted in the earlier part of this paper, was assumed to trap out the mammalian species concerned on one-eightieth of an acre. One unit of traps, as also previously explained, consists of one stationary line and one moving quadrat. The stationary line consists of three short lines of 33 traps each, and the moving quadrat during its period of operation is considered to trap an area equal to that of 14 short lines. Hence the whole unit is equivalent to 17 short lines operated for three-day periods. This means that an area equal to 17/80 of an acre is covered by the unit. In the example given in Table 15 there are three such units concerned, representing an area of 51/80 of an acre. Then, 80 divided by 51 gives us the factor 1.57, recorded in the table. Multiplying the actual catch by this factor, we get the catch per acre. Similar factors can be worked out for any number of units of traps, and from such calculations applied to the data of Table 9 we obtain the figures on population per acre as summarized in Table 16. The estimates on population per acre serve as a basis for the habitat and community studies to be discussed presently. At this time attention should, perhaps, in the interest of accuracy, be directed to one fact regarding estimates of populations, namely, that any such estimates are complicated by the wandering tendency of the individual species, or of the sexes, as mentioned in the preceding section. However, the method here described of using the three-day catch uniformly is perhaps as good as any other applicable in the circumstances, and it has the value at least of treating all the species concerned on the same basis.

Table 15 presents population estimates, per acre, as well as other data for the dry woods and moist woods habitats, in 1931. Tables 16 and 18 give a summary of such estimates of population per acre for each species in various habitats and seasons, and for the sexes considered together as well as separately. Table 17 is added for comparison, giving some of our earlier estimates of populations, at Brewerton, before our method had been fully developed and standardized.

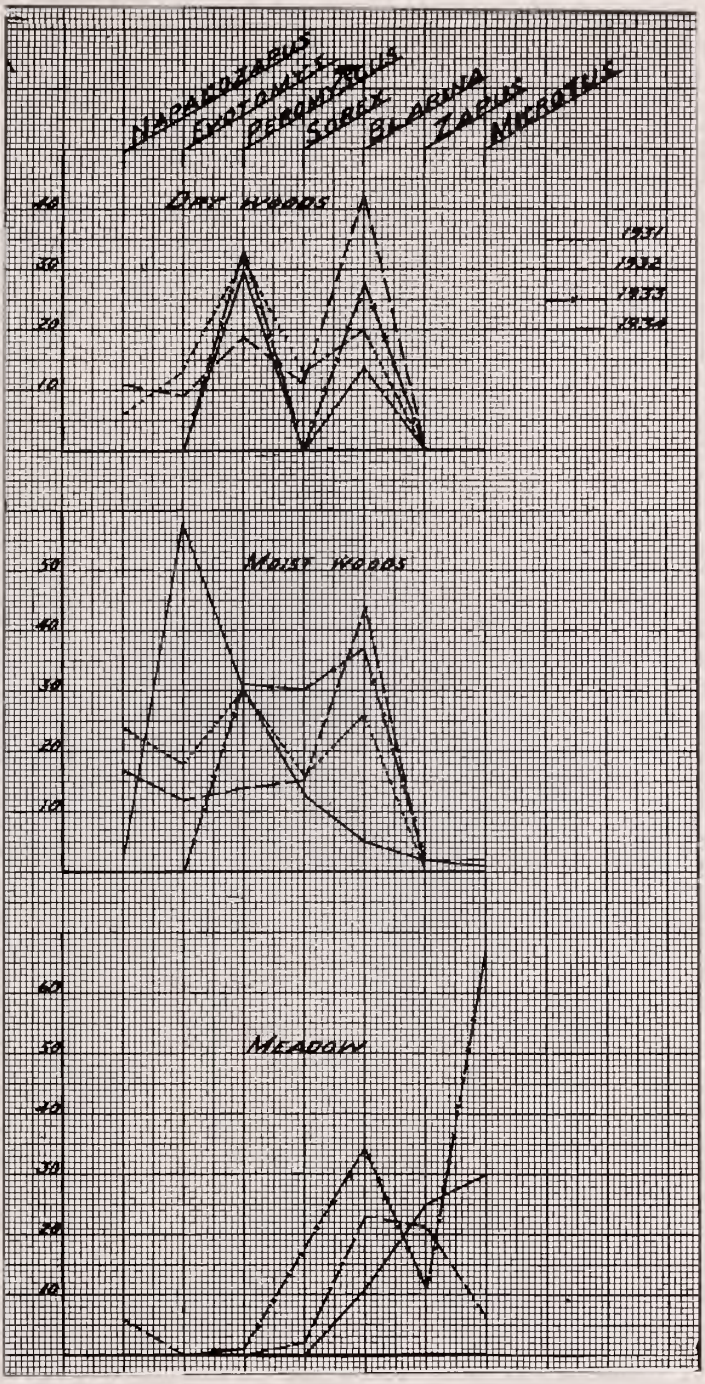


Plate. 4. Populations per acre. Plotted by species and habitats for each of four seasons. Data from Table 15.

TABLE 15. SHOWING METHOD OF ESTIMATING POPULATION PER ACRE, COMMUNITY PERCENT, HABITAT RATIOS AND HABITAT "PERCEPTION".
Data from Table 9.

	Blarina		Sorex		Peromyscus		Evotomys		Napaeozapus		
Dry woods (1931)	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	Totals
Catch (3 days)	7	6	7	1	8	12	3	5	2	2	
Three Units. Factor	1.57										
Population per acre	11 ← 9		11 ← 2		13 → 19		5 → 8		3	3	84
Community percent	13 ← 11		13 ← 2		15 → 23		6 → 10		4	4	
Population per acre											
Dry woods	11	9	11	2	13	19	5	8	3	3	84
Moist woods	13	13	13	3	8	22	2	16	11	13	114
Total	24	22	24	5	21	41	7	24	14	16	198
Habitat "selection" ratio											
Dry woods, percent	↓46	↑59	↓46	↓40	↑62	↓46	↑71	↓33	↓21	↓19	
Moist woods, percent	↓54	↑41	↓54	↓60	↑38	↓54	↑29	↓67	↓79	↓81	
Habitat "perception" value	8 → 18		8 → 20		24 ← 8		42 ← 34		58 → 62		

TABLE 16. POPULATION ESTIMATES PER ACRE OF CERTAIN SMALL MAMMALS.
Data from Table 9.

		Blarina	Sorex	Peromyscus	Evotomys	Zapus	Napaeozapus	Microtus	Totals (per acre)
Dry woods	1931	20	13	32	13	0	6	0	84
	1932	42	11	19	9	0	11	0	92
	1933	28	0	33	0	0	0	0	61
	1934	14	0	30	0	0	0	0	44
Moist woods	1931	26	16	30	18	0	24	0	114
	1932	44	15	14	12	0	17	0	102
	1933	37	30	31	0	2	0	2	104
	1934	5	13	30	58	3	2	2	113
Meadow	1932	23	2	0	0	21	6	6	58
	1933	34	18	1	0	11	0	67	131
	1934	11	0	0	0	25	0	30	66
Marsh	1934	4	10	1	0	7	0	24	46
Sweet flag	1933	4	23	0	0	9	0	54	90
Cedar-meadow	1933	28	53	16	0	2	0	34	133
Woods-meadow	1933	23	26	17	0	30	0	17	113
Dogwood	1933	38	28	33	0	14	0	9	122

TABLE 17. ESTIMATES OF POPULATION PER ACRE IN LOCALITIES NEAR BREWERTON, 1930. THREE-DAY CATCH IN ALL CASES, EXCEPT CONDYLURA AND PITYMYS WHICH REPRESENT A FIVE-DAY CATCH.

LOCALITY	Blarina	Sorex	Peromyscus	Zapus	Napaeozapus	Microtus	Condylura*	Pitymys*	Total
Low hummocky woods	30	0	10	0	10	0	0	0	50
Moist woods on hillside	66	0	12	0	0	0	6	6	90
Moist woods (M. Q. 4)	63	0	0	0	0	0	0	0	63
Weedy shore — Little Bay Creek	8	0	4	72	0	20	0	0	104
Swamp roadside	26	13	13	52	0	26	13	0	143
Tall grass and brush	37	63	0	7	0	17	3	0	127
Marsh	26	0	0	26	0	26	0	0	78
Tangle of weeds	104	0	0	0	0	13	0	0	117

TABLE 18. SUMMARY OF POPULATION PER ACRE FOR DIFFERENT SEASONS AND SEPARATE SEXES. 1931–1934.

		Blarina		Sorex		Peromyscus		Evotomys		Zapus		Napaeozapus		Microtus		
		F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	Totals
Dry woods	1931	11	9	11	2	13	19	5	8	0	0	3	3	0	0	84
	1932	12	30	6	5	8	11	3	6	0	0	3	8	0	0	92
	1933	5	23	0	0	7	26	0	0	0	0	0	0	0	0	61
	1934	5	9	0	0	9	21	0	0	0	0	0	0	0	0	44
Moist woods	1931	13	13	13	3	8	22	2	16	0	0	11	13	0	0	114
	1932	23	21	7	8	5	9	3	9	0	0	5	12	0	0	102
	1933	9	28	9	21	14	19	0	0	0	2	0	0	2	0	104
	1934	3	2	4	9	11	19	21	37	2	1	0	2	0	2	113
Meadow	1932	11	12	1	1	0	0	0	0	10	11	2	4	0	6	58
	1933	12	22	6	12	1	0	0	0	2	9	0	0	22	45	131
	1934	6	5	0	0	0	0	0	0	8	17	0	0	11	19	66
Marsh	1934	0	4	4	6	0	1	0	0	1	6	0	0	8	16	46
Cedar-meadow	1933	8	20	26	27	5	11	0	0	1	1	0	0	14	20	133
Woods-meadow	1933	14	9	5	21	5	12	0	0	14	16	0	0	5	12	113
Dogwood	1933	19	19	19	9	14	19	0	0	5	9	0	0	0	9	122
Sweet flag	1933	2	2	7	16	0	0	0	0	7	2	0	0	26	28	90

The contents of these tables will be utilized in the third section of this paper where each species is treated separately. At this time, however, attention will be directed to one or two general features which are brought out by a study of Table 16. In the last column, showing total catches per acre, we note that in the dry woods the populations per acre were higher in 1931 and 1932 than in the following seasons. This is probably due to the fact that at St. Mary's Pond and Constantia the dry woods closely adjoined the moist woods, and, therefore, probably more of the animals wandered into the former from the latter. In the moist woods, it will be noted, the population per acre is higher, ranging from 102 to 114 and showing remarkably uniform figures for the four seasons: that is, the total population appears to remain more uniform here than in the dry woods and in the meadow. Whether this is due to the uniformity of the habitat, involving perhaps moisture, and food in practically unvarying quantities during the summer months, or whether we did not succeed in classifying the meadow habitats with sufficient accuracy, is hard to determine. Meadow habitats undoubtedly show a wider range of conditions during the summer months than do the moist and shady low woods.

In Plate 4 populations per acre for several species are plotted by seasons for each habitat. The results give a strong indication that these species exert but little influence upon one another—in some respects, at least. Inspection of the graphs shows only a few suggestions of such interspecific effects. In the dry woods, for example, there is a suggestion that abundance of Blarina in 1932 tended to lower the abundance of Peromyscus, and that in 1931 and 1934 abundance of Peromyscus was associated with small numbers of Blarina. Again, in the moist woods the high population of Evotomys in 1934 seems to have been associated, to a slight extent, with a reduced population of Sorex and Blarina. But such was not true with Peromyscus, which was as numerous as in two other seasons. In meadow habitat a large population of Microtus, in 1933, was apparently associated with a rather large population of Blarina and a small population of Zapus. These apparent effects are not, however, very striking. But perhaps the influence of abundance of one species upon that of another might be more noticeable in a subsequent season in the same locality.

Community Percent

In Table 15 will be found the results of an attempt to estimate what percentage of the total population of a habitat each species represents. There were in this case, for example, an estimated 11 Blarina females per acre in a habitat where the total population of the five species represented was estimated as 84 per acre. It is a simple matter thereupon to determine that Blarina females made up 13% of the population, etc. Continuing the calculation for the other species, we obtain a picture of the makeup of the small-mammal community here represented. Table 19 gives results of this sort for all the species concerned, without reference to the separate sexes. The asterisks in this table indicate the most numerous species in each habitat for each season. Thus, in dry woods the "dominant" species were Blarina in one case, and Peromyscus in all others. The 1933 and 1934 seasons are in agreement in that the dry woods contained only these two species. In the other two seasons, Sorex, Evotomys and Napaeozapus were present.

In the moist woods, Table 19 indicates that the numerical dominants were at different times Blarina, Peromyscus and Evotomys. In meadow habitat, Microtus was dominant in two seasons, and Zapus in one.

In 1933, in the cedar-meadow habitat, Sorex was the dominant form, numerically; in the woods-meadow, Zapus; in the sweet flag marsh habitat, Microtus —which here constituted 60% of the population; in the sedge-marsh, Microtus (52%); and in the dogwood habitat, Blarina.

For the 1933 season it will be noted that four types of minor habitats were included, namely, dogwood, cedar-meadow, woods-meadow and sweet flag, each dominated by a different form, namely Blarina, Sorex, Zapus, and Microtus, in the order named. This suggests some possibility of a crowding-out effect among these forms.

TABLE 19. SUMMARY OF COMMUNITY PERCENTAGE VALUES LISTED ACCORDING TO VARIOUS HABITATS AND WITHOUT REGARD TO THE SEXES.

Data derived from Table 16. Highest percentage of catch for each season indicated by asterisk.

		Blarina	Sorex	Peromyscus	Evotomys	Zapus	Napaeozapus	Microtus
Dry woods	1931	24	15	*38	15	0	8	0
	1932	*45	12	21	10	0	11	0
	1933	46	0	*54	0	0	0	0
	1934	32	0	*68	0	0	0	0
Moist woods	1931	22	14	*27	16	0	21	0
	1932	*43	15	14	12	0	16	0
	1933	*36	29	30	0	2	0	2
	1934	4	12	27	*51	2	0	2
Weed-meadow	1932	40	3	0	0	*37	10	10
	1933	26	14	1	0	8	0	*51
	1934	17	0	0	0	38	0	*45
Cedar-meadow	1933	21	*39	12	0	2	0	26
Woods-meadow	1933	20	23	15	0	*26	0	15
Sweet flag	1933	4	26	0	0	10	0	*60
Marsh	1934	9	22	2	0	15	0	*52
Dogwood	1933	*31	23	27	0	11	0	7

TABLE 20. SUMMARY OF COMMUNITY PERCENTAGE VALUES FOR CERTAIN SMALL MAMMALS ARRANGED ON THE BASIS OF TYPES OF HABITAT AND WITH THE SEXES CONSIDERED SEPARATELY.

Data from Table 18.

	Blarina		Sorex		Peromyscus		Evotomys		Zapus		Napaeozapus		Microtus	
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
Dry woods 1931	13	← 11	13	← 2	15	→ 23	6	→ 9	0	0	4	4	0	0
1932	13	→ 32	7	← 5	9	→ 12	3	→ 7	0	0	3	→ 8	0	0
1933	8	→ 38	0	0	11	→ 43	0	0	0	0		0	0	0
1934	11	→ 21	0	0	21	→ 47	0	0	0	0	0	0	0	0
Moist woods 1931	11	11	11	← 3	7	→ 20	2	→ 14	0	0	10	11	0	0
1932	23	← 20	7	→ 8	5	→ 9	3	→ 9	0	1	5	→ 11	0	0
1933	9	→ 27	9	→ 20	13	→ 17	0	0	0	2	0	0	2	0
1934	2	2	4	→ 8	10	→ 17	18	→ 33	1	1	0	0	0	2
Meadow 1932	20	20	2	2	0	0	0	0	18	19	3	7	0	→ 10
1933	9	→ 17	5	→ 9	1	0	0	0	2	→ 7	0	0	17	→ 34
1934	9	8	0	0	0	0	0	0	12	→ 26	0	0	17	→ 28
Cedar-meadow 1933	6	→ 15	19	20	4	→ 8	0	0	1	1	0	0	11	→ 15
Woods-meadow 1933	12	← 8	4	→ 19	4	→ 11	0	0	12	→ 14	0	0	4	→ 11
Sweet flag 1933	2	2	8	→ 18	0	0	0	0	8	← 3	0	0	29	→ 31
Marsh 1934	0	→ 9	9	→ 13	0	2	0	0	2	→ 13	0	0	17	→ 35
Dogwood 1933	16	16	16	← 7	11	→ 16	0	0	4	→ 7	0	0	0	→ 7

Table 20 shows a similar summary of community percentages arranged according to the separate sexes for each form. We note here that in many instances the sex ratios differ in various habitats, as indicated by the arrows which point toward the higher percentage in each pair of values. Conclusions that might be drawn from this table will be discussed for each form separately in a later section of the paper.

Habitat "Selection" Ratios

Which of two contiguous habitats is more frequented by a given species of mammal? An attempt to attack this question is also shown in Table 15, under the heading of habitat ratio. The method used may be applied to any two habitats which are in rather close contact. In the example chosen, dry woods are compared with near-by moist woods. Eleven female Blarina per acre for the dry woods are added to thirteen female Blarina per acre for the moist woods, and the percentage determined for each, thereby giving a ratio which expresses the animal's "selection" with regard to the two habitats. Thus, the dry woods-moist woods ratio for female Blarina in this instance was 46 to 54. This we shall call the habitat "selection" ratio.

Table 21 shows the ratios for all the forms concerned in the various habitats and seasons, irrespective of the sexes. Arrows pointing from the lower to the higher number in each instance show at a glance the direction of the "selection". Most of the forms appear to "prefer" moist woods to dry woods. Other conclusions may best be discussed in later sections dealing with individual species concerned.

Table 22 gives the results of similar studies where the sexes are considered separately. We note that the males do not always "prefer" the same habitat as do the females, in the cases of Blarina, Peromyscus, Zapus and Microtus. However, Sorex and Napaeozapus seem to show similar habitat "preferences" for the two sexes. Whether these results are due to reaction to environment or to a driving out of one sex by the other is hard to say at present.

Habitat "Perception"

The study of habitat ratios may be carried further by attempting to show not merely the direction of "selection", or "preference", but also the degree. This is here called the habitat "perception", and the method of deriving it is indicated in Table 15. By subtraction the amount of difference between the two habitat ratio values is obtained. Thus, in the instance given, a dry woods percentage of 46 subtracted from a moist woods percentage of 54 gives a "perception" value of 8 for female Blarina. A corresponding value for the males is 18, indicating apparently a much greater degree of "selection" of habitat, in this instance, on the part of the males.

Table 23 gives habitat "perception" values for the forms concerned, in various contiguous habitats. Blarina for example, shows a low "perception" as between dry woods and moist woods, and among other types of habitat it seems to vary a good deal in different seasons. Peromyscus, Evotomys, Zapus and Microtus show high "perception" as between moist woods and meadow, etc. Table 24 gives similar data with the sexes considered separately. Further discussion of this table is deferred to later paragraphs dealing with the separate forms.

TABLE 21. HABITAT "SELECTION" RATIOS.

In each case the relative abundance (without regard to sex) of the form is given for two contiguous habitats.

	Blarina brevicauda	*Sorex cinereus* plus *fumeus*	*Peromyscus, m. gracilis* plus *l. nov'b.*	*Evotomys gapperi*	*Zapus hudsonicus*	*Napaeozapus insignis*	*Microtus pennsylvanicus*	Year
Dry woods	↓ 43	↓ 45	↑ 52	↓ 42	.....	↓ 20	.....	.....
vs.	↓ 57	↓ 55	↑ 48	↓ 58	.....	↓ 80	.....	1931
Moist woods								
	↓ 49	↓ 42	↑ 58	↓ 43	.....	↓ 39	.....	1932
	↓ 51	↓ 58	↑ 42	↓ 57	.....	↓ 61	.....	.....
	↓ 43	↓ 0	↑ 52	0	↓ 0	0	↓ 0	1933
	↓ 57	↓ 100	↑ 48	0	↓ 100	0	↓ 100	.....
Moist woods	↑ 67	↑ 88	↑ 100	↑ 100	↓ 0	↑ 74	↓ 0	1932
vs.	↑ 33	↑ 12	↑ 0	↑ 0	↓ 100	↑ 26	↓ 100	.....
Meadow								
	↑ 52	↑ 63	↑ 97	.....	↓ 15	.....	↓ 2	1933
	↑ 48	↑ 37	↑ 3	.....	↓ 85	.....	↓ 98	.....
	↓ 31	↑ 100	↑ 100	↑ 100	↓ 11	.....	↓ 6	1934
	↓ 69	↑ 0	↑ 0	↑ 0	↓ 89	.....	↓ 94	.....
Meadow	↑ 73	↓ 0	↓ 0	.....	↑ 78	.....	↑ 56	1934
vs.	↑ 27	↓ 100	↓ 100	.....	↑ 22	.....	↑ 44	.....
Marsh								
Meadow	↑ 55	↓ 25	↓ 6	.....	↑ 85	.....	↑ 66	1933
vs.	↑ 45	↓ 75	↓ 94	.....	↑ 15	.....	↑ 34	.....
Cedar-meadow								
Meadow	↑ 89	↓ 44	↓ 0	.....	↑ 55	.....	↑ 55	1933
vs.	↑ 11	↓ 56	↓ 100	.....	↑ 45	.....	↑ 45	.....
Sweet flag								
Sweet flag	↓ 12	↓ 31	.....	.....	↑ 82	.....	↑ 61	1933
vs.	↓ 87	↓ 69	.....	.....	↑ 18	.....	↑ 49	.....
Cedar-meadow								

TABLE 22. SUMMARIZING HABITAT "SELECTION" RATIOS, ARRANGED ACCORDING TO THE SEXES FOR EACH FORM.

HABITAT	Blarina F.	Blarina M.	Sorex F.	Sorex M.	Peromyscus F.	Peromyscus M.	Evotomys F.	Evotomys M.	Zapus F.	Zapus M.	Napaeozapus F.	Napaeozapus M.	Microtus F.	Microtus M.	Year
Dry woods	↓ 46	↓ 41	↓ 46	↓ 40	↑ 62	↓ 46	↑ 71	↓ 33	0	0	↓ 21	↓ 19	0	0	1931
vs.	↓ 54	↓ 59	↓ 54	↓ 60	↑ 38	↓ 54	↑ 29	↓ 67	.....	.....	↓ 79	↓ 81	.....	....	....
Moist woods															
	↓ 27	↑ 59	↓ 46	↓ 38	↑ 62	↑ 55	50	↓ 40	0	0	↓ 37	↓ 40	0	0	1932
	↓ 73	↑ 41	↓ 54	↓ 62	↑ 38	↑ 45	50	↓ 60	.....	.....	↓ 63	↓ 60	.....	....	....
	↓ 36	↓ 45	↓ 0	↓ 0	↓ 33	↑ 53	0	0	0	0	0	0	0	0	1933
	↓ 64	↓ 55	↓ 100	↓ 100	↓ 67	↑ 47	.....	.....	.....	.....	.....	....	.....	....	....
Moist woods	↑ 68	↑ 64	↑ 87	↑ 89	↑ 100	↑ 100	↑ 100	↑ 100	↓ 0	↓ 0	↑ 71	↑ 75	0	↓ 0	1932
vs.	↑ 32	↑ 36	↑ 13	↑ 11	↑ 0	↑ 0	↑ 0	↑ 0	↓ 100	↓ 100	↑ 29	↑ 25	0	↓ 100	....
Meadow															
	↓ 43	↑ 58	↑ 60	↑ 64	↑ 93	↑ 100	0	0	↓ 0	↓ 18	0	0	↓ 8	↓ 0	1933
	↓ 57	↑ 42	↑ 40	↑ 36	↑ 7	↑ 0	.....	.....	↓ 100	↓ 82	.....	....	↓ 92	↓ 100	....
	↓ 33	↓ 28	↑ 100	↑ 100	↑ 100	↑ 100	↑ 100	↑ 100	↓ 20	↓ 6	0	0	↓ 0	↓ 10	1934
	↓ 67	↓ 72	↑ 0	↑ 0	↑ 0	↑ 0	↑ 0	↑ 0	↓ 80	↓ 94	.....	....	↓ 100	↓ 90	....
Meadow	↑ 100	↑ 56	↓ 0	↓ 0	0	↓ 0	0	0	↑ 88	↑ 74	0	0	↑ 58	↑ 54	1934
vs.	↑ 0	↑ 44	↓ 100	↓ 100	0	↓ 100	.....	....	↑ 12	↑ 26	.....	..	↑ 42	↑ 46	....
Marsh															
Meadow	↑ 60	↑ 52	↓ 19	↓ 31	↓ 16	↓ 0	0	0	↑ 67	↑ 90	0	0	↑ 61	↑ 69	1933
vs.	↑ 40	↑ 48	↓ 81	↓ 69	↓ 84	↓ 100	.....	....	↑ 33	↑ 10	.....	....	↑ 39	↑ 31	....
Cedar-meadow															
Sweet flag	↓ 20	↓ 9	↓ 21	↓ 37	0	0	0	0	↑ 88	↓ 67	0	0	↑ 65	↑ 58	1933
vs.	↓ 80	↓ 91	↓ 79	↓ 63	....	.....	. ....	....	↑ 12	↑ 33	.....	....	↑ 35	↑ 42	....
Cedar-meadow															
Meadow	↑ 86	↑ 92	↓ 46	↓ 43	↑ 100	0	0	0	↓ 22	↑ 82	0	0	↓ 46	↑ 62	1933
vs.	↑ 14	↑ 8	↓ 54	↓ 57	↑ 0	0	.....	....	↓ 78	↑ 8	.....	....	↓ 54	↑ 38	....
Sweet flag															

TABLE 23. SUMMARY OF HABITAT "PERCEPTION" VALUES, WITHOUT REGARD TO SEX. Data from Table 21.

HABITAT	Blarina	Sorex	Peromyscus	Evotomys	Zapus	Napaeozapus	Microtus	Year
Dry woods vs. Moist woods	14	10	4	16	.....	60	.....	1931
	2	16	16	14	.....	22	.....	1932
	14	100	4	.....	.....	.....	100	1933
Moist woods vs. Meadow	34	76	100	100	100	48	100	1932
	4	26	94	.....	70	.....	96	1933
	48	100	100	100	78	.....	88	1934
Meadow vs. Marsh	46	100	100	.....	56	.....	12	1934
Meadow vs. Cedar-meadow	10	50	88	.....	70	.....	32	1933
Meadow vs. Sweet flag	78	12	100	.....	10	.....	10	1933
Sweet flag vs. Cedar-meadow	75	38	.....	.....	64	.....	12	1933

TABLE 24. SUMMARY OF HABITAT "PERCEPTION" VALUES, LISTED WITH REFERENCE TO THE SEPARATE SEXES OF THE MAMMAL FORMS CONCERNED. Data from Table 22.

HABITAT	Blarina		Sorex		Peromyscus		Evotomys		Zapus		Napaeozapus		Microtus		Year
	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	
Dry woods vs. Moist woods	8	18	8	20	24	8	42	34	.....	.....	58	62	.....	.....	1931
	46	18	8	24	24	10	0	20	.....	.....	26	20	.....	.....	1932
	28	10	100	100	34	6	.....	.....	.....	.....	.....	.....	.....	.....	1933
Moist woods vs. Meadow	36	28	74	78	100	100	100	100	100	100	42	50	0	100	1932
	14	16	20	28	86	100	.....	.....	100	64	.....	.....	84	100	1933
	34	44	100	100	100	100	100	100	60	88	.....	.....	100	80	1934
Meadow vs. Marsh	100	12	100	100	0	100	.....	.....	76	48	.....	.....	16	8	1934
Meadow vs. Cedar-meadow	20	4	62	38	68	100	.....	.....	34	80	.....	.....	22	38	1933
Meadow vs. Sweet flag	72	84	8	14	100	.....	.....	.....	56	64	.....	.....	8	24	1933
Sweet flag vs. Cedar-meadow	60	82	58	26	.....	.....	.....	.....	76	34	.....	.....	30	16	1933

The Small-Mammal Community

The present study as it developed came to include all the small mammals found together in each of several habitats. These mammals in one sense constitute a "community". They are all of about the same size,—small enough to be taken in the ordinary mouse-trap; they are all quick in their movements, and they occupy the same ground in woods or meadow. Doubtless any one of these forms is influenced more or less by the others living near it. It sees one or more of the others occasionally, hears the sounds they make,—both the vocal sounds and the rustling of the leaves and the grass as they move about. It encounters the odors of the other forms, and comes upon their burrows, feeding spots and excreta. Unquestionably these other little mammals, both of its own kind and of different kinds, constitute a very real factor of its habitat.

Of course, other animal forms besides mammals are important as a part of the "mouse" community, also. The weasel, the mink, the owl, the hawk, and perhaps

certain snakes, are predators which may profoundly influence the mouse population. The chipmunk, the squirrel, smaller birds, and perhaps to a lesser extent the raccoon, the skunk and the frog are competitors or associates of these small mammals, while the arthropods, the molluscs and the annelids may play the role of food for some and of competitors or mere associates for others of the small-mammal community. Indirectly these latter forms, as, for example, through their relation to (food) plants, exert some influence, probably, on much of the other animal life of the forest.

All the various kinds of animals found within a given area probably also exert some influence upon one another. Together they constitute the animal community as a whole and present problems of great complexity to the student of ecology. In the present instance the study has been limited to the small-mammal community only, overlooking for the time being other animals within the same areas.

The small-mammal population per acre in certain habitats is a subject worthy of discussion, as is likewise the proportional part of this population represented by each species. Table 16 summarizes the results of population estimates per acre, for the four seasons covered by the present studies. The total population figures per acre appear in the column at the extreme right. This represents the concentration of the small-mammal community as a whole, in each type of habitat. We note that in dry woods, that is, along the ridge tops, the total populations for two seasons were nearly the same, 84 and 92, respectively. Yet the proportions of the different forms were different in the two seasons, as indicated in the "community percentage" figures in Table 19. Thus, in 1931, Blarina constituted 24% of the community; in 1932 and 1933, 45% and 46%; and in 1934, 32%. Other forms also differ in this respect. Peromyscus constituted 38%, 21%, 54% and 68%, in four consecutive seasons. In 1933 and 1934 only two forms were taken in this habitat, namely Blarina and Peromyscus. This suggests that the available territory will hold a certain number of small mammals, and that when Blarina is abundant, Peromyscus is less abundant, or vice versa. A given area apparently has room for only a certain number of these small mammals, regardless of species. In this connection, Hatt ('30, pp. 606–609), quoting from the literature, indicates that in times of mouse plagues, as a result of overcrowding, breeding activities cease. This has also been shown for several invertebrate species (Chapman, '29, etc.). As pointed out by Johnson ('26) this principle may have an important bearing on the stocking of a game preserve. He says (p. 11) that the "size of territory is a most important limiting factor, and in some cases the deciding factor as to the quantity of game that can be produced on a given tract, even with optimum conditions of habitat. . . . Various species have their home range, individual or family, and excepting such forms as may be more or less colonial or social in habits, are inclined to seek their distances from neighbors of their own kind."

Heape ('31, Chapter 2) also has called attention to the fact that most animals have a deep-seated respect for the occupied territory.

This would seem to indicate that a game refuge, for example, is not likely to become overstocked where the game has a chance to "spill over" into surrounding

or adjoining areas. Just what the inhibiting factor governing the community populations may be, is rather uncertain. It appears often to be something other than food supply. Possibly some factor of tolerance (as above quoted) for another animal in the vicinity enters in; or possibly each individual animal (of some species) must have a certain amount of space to move about in without encountering others of its own or of other kind.

Study of the data for the moist woods habitat (Table 16) reveals less variation here in the total populations per acre, the figures being 114, 102, 104, 113; but this seems to be true in general for the moist woods populations. Probably it is due to a lesser amount of variation in the moist woods habitat. However, study of the moist woods data of Table 19 shows the same apparent varying numerical preponderance among the different forms that were noted in the dry woods. Apparently Blarina constituted 22%, 43%, 36% and 4%, respectively, of the community population in the four seasons. Peromyscus varied from 14% to 30%. For the 1931 and 1932 seasons the populations of Sorex, Napaeozapus and Evotomys showed no important change.

Turning now to the meadow community (Tables 16 and 19), we note a similar situation. The population estimates per acre were 58 in 1932, 131 in 1933, and 66 in 1934. We note from Table 19 that the balance between forms was decidedly at variance in the three seasons. Zapus seems to show practically the same numerical status in two seasons, 1932 and 1934, when the total population was low, namely 37% and 38% (Table 19). Blarina varies from 17% to 40%; Sorex from 0% to 14%; Microtus from 10% to 51%. Napaeozapus was found in the meadows in 1932, and Peromyscus was found there to some extent in 1933. The three seasons show no correlation as to the different forms, except a suggestion that an abundance of Blarina is correlated with a scarcity of Microtus.

Indications of Social Tendencies

An approximate method of studying social tendencies, or toleration for others among members of a species, was used as follows: The data from the trap lines were examined and cases where two or more individuals of a species were taken on one group of 99 traps in one day's period were tabulated as shown in Table 25. In this table it will be noted that each such catch is listed according to its general makeup, i. e., loose groups of one male and one female caught in the same night as well as groups of two males, two females, etc., being listed in order. It is likely that these observations do not necessarily mean that the two or more animals caught in one night on a line of traps were socially "fraternizing" together; they may have been caught on the same line by chance. Such a line of traps is about 100 feet long and may perhaps, also, overlap two separate territories occupied by two animals. Thus the results may mean that the two individuals lived in near-by territories; or they may mean that the animals were really "keeping company" at the time. The catching of two individuals on the same line in one night may thus mean a social tendency, a nearness of their individual territories, or a tolerance for each other in the same territory. However, the results indicated in the table are suggestive of some possible conclusions. We note, for example, that Blarina and Napaeozapus were never taken in numbers greater than three

on any trap unit in a single night. Also we note that two Blarina females were taken on the same line in the same night 14 times,—nearly as often as two males were thus taken—while for other forms listed there is a notable scarcity of catches of two females near each other. This may possibly be correlated with the data from pregnancies and other considerations which indicate that perhaps Blarina was being taken between two breeding seasons, while some of the other forms were being taken during breeding seasons, when the females would probably discourage the presence of others of the same sex in the locality.

At the bottom of Table 25 is summarized the calculated percentages of all catches which involved only one individual of the given form on a line—in other words, "single" catches. While the method is subject to a considerable amount of possible error due to chance, some of the results seem suggestive and may perhaps be further developed by future study. We note that all the forms listed were taken more often as "single catches" than otherwise, values ranging from Sorex, taken singly in 58% of the catches, to Zapus taken thus in 74% of the cases.

Table 25. Presenting Possible Indications of Social Tendency or Toleration Among Certain Small Mammals, as Shown by the Number of Times That More Than One Individual of a Given Form Were Taken on a Trap Line in a Single Night. Data from 1931, 1932, 1933 and 1934.

		Number of Times Taken						
"Group" size	"Group" content	Blarina	Sorex cinereus	Peromyscus l. nov.	Evotomys	Zapus	Napaeozapus	Microtus
	Females & *Males*							
2.....	1 & 1	32	19	22	17	10	2	18
	0 & 2	15	21	11	19	5	6	11
	2 & 0	14	3	3	2	3	2	2
3.....	1 & 2	6	3	2	3	1	3	2
	2 & 1	4	1	1	2	2	0	1
	0 & 3	4	2	1	4	1	0	1
	3	4	0	1	1	0	2	0
4.....	3 & 1	0	2	0	1	0	0	0
	2 & 2	0	1	0	0	0	0	1
	4	0	1	0	1	0	0	0
5.....	1 & 4	0	1	1	0	0	0	0
	5	0	0	0	0	0	0	1
6.....	1 & 5	0	0	0	1	0	0	0
Total no. of "group" catches.....		79	54	42	51	22	15	37
Number of individuals taken in "groups".....		176	125	92	120	48	35	83
Total no. of individuals caught—singly and in groups.....		620	288	235	318	187	125	281
Percentage of "single" catches.....		72	58	61	62	74	72	70

PART II. NOTES ON THE BIOLOGY OF CERTAIN SMALL MAMMALS

BLARINA BREVICAUDA BREVICAUDA (SAY)

The commonest mammal caught with the traps in many localities was the short-tailed shrew. The species was taken in all of the localities studied, but its abundance varied considerably. Wherever small mammals were found in any numbers, there Blarina would appear in the traps sooner or later, usually among the earliest catches. At Brewerton, in 1930, we found Blarina numerically dominant in some habitats, constituting 84% of the small-mammal population in one section of the moist woods on Hoyt's farm, and occurring in one weed patch to the extent of an estimated 104 individuals per acre (Table 17). In the St. Mary's Pond district, in 1931, this species constituted about 22% to 24% of the small-mammal population in the woods habitat (Table 19). In the Constantia district, 1932, it constituted an estimated 45% of this population of the dry woods habitat; 43% of the low woods habitat; and 40% in the meadow habitat. At Marcellus, in 1933, these shrews were likewise abundant, constituting 46% in the dry woods habitat, 36% in the moist woods, and 26% of the meadow.

This species appears to show but little habitat "preference". It is equally at home in dry woods, moist woods and wet meadows, provided food and burrowing possibilities are ample for its needs. Reference to Table 21 indicates that for three seasons Blarina was found to have a dry woods-moist woods ratio of about 45 to 55. This ratio suggests a slight "preference" for the moist woods habitat. In this connection Harper ('29) found Blarina in the Adirondacks more abundant near streams, "and to a considerably less extent in the drier parts of the woods". A study of habitat "preference" by sexes, Table 22, indicates a slight attraction of males to dry woods, and females to moist woods. Perhaps during the summer months, between breeding seasons, the sexes are to some extent antagonistic. Further data from Table 21 suggest that the animal usually is found more often in moist woods than in meadow, and more often in meadow than in some of the other habitats listed.

Blarina is decidedly an animal of the burrows and runways. The open-cover-burrow ratio is usually high on the burrow end of the scale, 9–16–75; 22–14–64, etc., as shown in Table 8. No doubt this preference for the covered passageways is the reason for its apparent low habitat "perception". In burrows the conditions are likely to be similar whether they are in the woods or in the meadow. Temperature, humidity and light, for example, will not vary as much there as they do on the surface of the ground.

The burrows vary somewhat with the surroundings. In dry woods Blarina tunnels beneath the layer of dead leaves on the ground, probably coming out onto the surface only occasionally. In moist woods it may follow tunnels which frequently take on the character rather of trenches on the ground surface, in places partly covered perhaps by roots and twigs, but occasionally lying deeper and assuming true tunnel form. In Hoyt's Woods, at Brewerton, some of these passages were found to have a "double-decked" arrangement. At first sight they

appeared to be mere trenches with a leaf-mold bottom, but occasionally a burrow appeared below the leaf-mold layer. Perhaps both levels are used, the animal seeking the lower one during dry periods. In meadows the animal follows indistinct surface runways, while in low woods the burrows commonly occur just below the mossy covering of the hummocks. Frequently in such locations one may note a small opening over a burrow in the side of the hummock which seems to indicate that the animal, while scurrying along beneath the moss, had accidentally penetrated to the surface. The results of trapping just outside of these holes indicates that they are used to some extent as exits from the underground tunnels. Some may perhaps serve as "windows". While watching these shrews in their trenches and burrows around a mossy log in Hoyt's woods, I frequently saw them pass such holes on their way to a more open trench. In this connection Hamilton ('31) says of the runways that, ". . . . there appear to be two zones, one a few inches below the surface, and one at a considerably deeper level." Shull ('07) says, "Blarina burrows at surface resemble those of Microtus, but when they enter the ground, they do so at a steeper angle." He finds that Blarina burrows occasionally have two openings not less than a meter apart, while in Microtus burrows the openings may be only 35 or 40 centimeters apart.

The food of Blarina has been discussed by a number of authors. Seton mentions it as consisting of "chiefly insects and worms", but he also mentions field mice, and one odd case where the animal ate cracked corn. He discusses the "enormous appetite which must be satisfied or in a few hours the creature succumbs". Shull ('07) made a careful study of the diet of Blarina and estimated its monthly food consumption to consist of about 40% voles, 20% adult insects, 20% immature insects, 5% earthworms, and 15% snails. Hamilton ('30) lists the following food percentages: insects, 47.8; plants, 11.4; annelids, 7.2; crustaceans, 6.7; mollusks, 5.4; vertebrates, 4.1; centipedes, 3.8; arachnids, 2; and millipedes, 1.7. The same author (l. c., p. 34) says that "one half the shrew's weight in food is ample for it over a 24-hour period."

No doubt the diet varies with the available food supply. In an area like Hoyt's woods, where Blarina constituted about 84 per cent of the small-mammal population, its diet could hardly have included many mice, and it must have been feeding chiefly on invertebrates. A study of stomach contents of Blarina, in conjunction with a study of the small-mammal population, would perhaps be of value. Various authors have described the killing of a mouse by a Blarina and there seems to be a possibility that this prowess of the shrew may be a limiting factor in the abundance of other small mammals, as discussed in another part of this paper. Cope ('73) and Roosevelt ('07) have each described the killing and eating of a snake by this shrew.

Water is supposed to be an important item in the diet of the Blarina. Seton ('09, p. 1129) says that "all the shrews are heavy drinkers". In the present study a shrew taken alive in a weasel trap at Marcellus seemed almost dead when found, but revived quickly when sprinkled with water, which it then began to lap up greedily. However, a caged individual at St. Mary's Pond seemed to drink less than certain other small mammals kept in captivity at the same time. Nevertheless

Fig. 17. General view of sweet flag habitat at Mud Pond, Marcellus. A belt of cedar woods in the middle distance. July, 1933. Photograph by John Pearce.

Fig. 18. Brush and weed cover along stone wall at South Pond, Constantia. A few Blarina occupied the tall weeds.

Fig. 19. Blarina nest in old stump hummock. Nest of dry leaves and grass may be seen just in front of nest cavity. Note peaty nature of hummock. Sadler's woods near Brewerton. August 19, 1930.

Fig. 20. Sorex nest in low hummock at base of elm tree. Nest cavity is at right of notebook. Nest material of fine grass on notebook (6 x 9 inches). Sadler's woods near Brewerton. August 19, 1930.

it is possible that thirst rather than hunger is the cause of death of many Blarinas caught in live traps.

During the summer of 1931, at St. Mary's Pond, a caged Blarina was kept under observation for several weeks. Like other small mammals in our cages at that time, it was offered a variety of food. It would not eat any vegetable matter, but readily took bacon, hard-boiled eggs, and especially the carcasses of mice which were placed before it daily. Of these carcasses it ate a surprising number,—bones and all, judging by the absence of remains found in the cage when it was later cleaned out. The animal became exceedingly fat during the period it was under observation. The following account of its behavior at one feeding period was recorded by Mr. Pearce, assistant.

"July 24. Blarina comes up on top of litter in open and smells about, pointing toward dead mouse near cage door. Immediately ducks into hollow log and then makes its way under the leaves to the mouse, smells it over once or twice and then seizes it by the neck and drags it out of sight, without any apparent effort. I tied the next mouse by the tail to the door of the cage with a fine wire. Blarina soon came out from under a stick, nose twitching and nearly describing a circle. Then it eagerly seized the mouse by the skin between the eye and the vibrissae, tugging hard. This being of no avail, it next tried a front, then a hind, foot. Apparently becoming irritated, it climbed upon the mouse, biting it here and there, then began to concentrate on the base of the tail, where the mouse was fastened. It was difficult for the shrew to get a good bite on account of the wire. At times, when it was working at the tail, it would brace its feet against the mouse and tug; while its feet slipped, it retained its hold. It did not once stop to eat, but worked very fast, seemingly determined to get the mouse under cover. When it finally had gnawed the tail in two, it dragged the mouse underneath the hollow stick, as before.

"While it was working it evidently depended on its ears to warn it of danger, for it scurried to cover at each little sound. It did not feel around or seek for the entrance under the stick, but each time ran directly to it without the least hesitation."

This behavior of a caged individual is probably typical of Blarina in its native haunts. It has a voracious appetite, but approaches its meal if possible under cover, seizes the food and then hastily retreats.

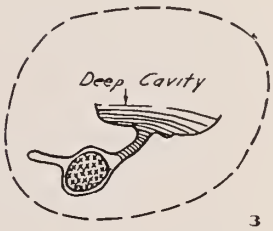
During the summer of 1930, several days were spent in observations on Blarina in the moist woods at Hoyt's farm. Here, if one remained quiet beside a decaying log for a few minutes, one could easily catch a glimpse of a soft-grey form darting across the opening in one of the numerous burrows that were partly exposed underneath the log. A series of experiments were made by tying a small piece of bacon rind to a length of colored thread and leaving it in an open spot in a runway. Several such baited threads were usually distributed at favorable points, each fastened to a stick. A few minutes later one or more of the baits would be found to have vanished, having been dragged into a burrow. This indicated where the animals were active at the time. Another piece of bacon would then be placed and the spot watched carefully. Soon a Blarina would approach along the burrow, perhaps showing itself momentarily at some opening

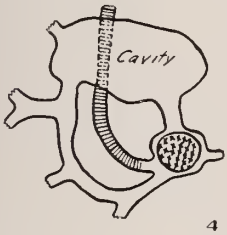
farther away, then appearing at the feeding spot. Invariably it scurried rapidly along the burrow, till it reached the opening; then a moment of hesitation would follow, while the sensitive nose twitched this way and that, when the animal would dart out, seize the bacon and dart back into the burrow from which it had emerged. Evidently the animal was uneasy in the open spot and felt safe only in the shelter of its burrow. This, of course, agrees with the data from the trap lines which show a high "preference" for burrow sets rather than for the cover or the open sets.

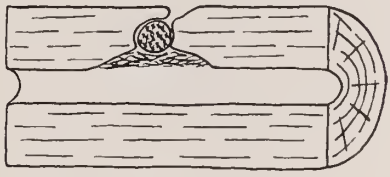
In a further series of experiments, a "spool-bait" method was used, a piece of bacon being tied to a thread wound on a spool in such a way that it would unwind easily. Next day many of the threads would be found to have been unwound, and led through the maze of burrows for varying distances. Sometimes the bacon had been finally torn from the anchoring thread, at other times it had been abandoned. In one instance the thread was followed a distance of thirty feet, into a large hummock. Additional threads led from other directions toward this hummock, and accordingly a careful search was made here for a possible nest of Blarina. The hummock consisted of peaty material, easily excavated, and in the center of it was found an old nest.

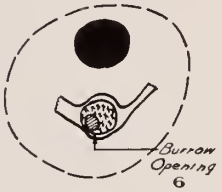
Observations of this sort in cage and field have corroborated the views of others that Blarina is inclined to hoard food. The bacon offered was carried away in most cases before being eaten. The same was true of peanuts similarly placed in the runways. A dead shrew placed in a used burrow disappeared in a short time. Hamilton ('31) mentions the hoarding habit of Blarina, and Merriam ('95) says that "It looks as though the animal was in the habit of hoarding for winter". Shull ('07) studied Blarina in winter and found it gathering snails which it piled up on the ground surface when the temperature rose. In cool weather the snails were stored in small chambers in the burrows. He also mentions the fact that Blarina sometimes hoarded the bodies of mice, but did not move them about.

The senses of Blarina have been studied to some extent by several authors. All agree that the animal has poor eyesight, though Hamilton ('31) believes it distinguishes more than just shadows. Ryder ('88) has shown that anatomically the eye is capable of adjustment for the direction of vision. Shull ('07), from certain experiments concluded that the muscular sense of Blarina was slight, the tactile sense acute, especially around the vibrissae, the sight poor and the hearing acute. The animal became indifferent to various sounds after they had been repeated several times, with the exception of the sound of a bird's wings, which continued to send the animal scurrying to cover. This suggests that the animal had learned to associate such sounds with the approach of an enemy. But Montgomery ('99), who studied the pellets of owls, found that shrew remains were scarce. Chas. J. Spiker, also, in an unpublished note, has found that the winter pellets of owls show but few Blarina remains. This is presumably due to the burrowing habits of the shrew, but it may also be due in part to a high sensitivity of the animal in detecting approaching enemies. According to Shull, ('07), the sense of smell is acute in Blarina, enabling it to distinguish between empty snail shells and occupied ones. Klugh ('21) says of these shrews: "In









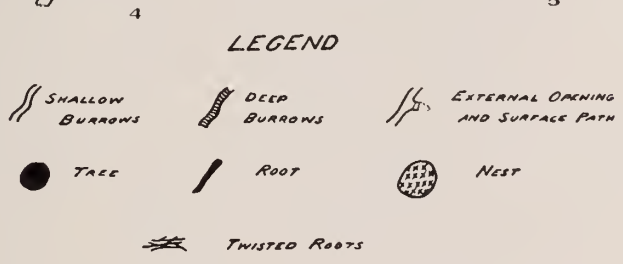


Plate 5. Plan of nest and burrows of Blarina and Sorex as found in the Brewerton region.

Fig. 1. Blarina nest in Hoyt's woods.
Fig. 2. Diagram of basswood hummock, showing location of Blarina nest. Hoyt's woods.
Fig. 3. Diagram of nest of Blarina(?), or possibly Sorex(?), made of dry leaves. In hummock (outlined with broken line) in Sadler's woods.
Fig. 4. Vertical diagram of nest of fine dry grass in old rotten log, probably Sorex. Sadler's woods.
Fig. 5. Side view of nest of dry fine grass probably made by Sorex. In old log in Sadler's woods.
Fig. 6. Vertical view of nest, in old hummock, made of dry fine grass. Probably nest of Sorex. Sadler's woods.
Fig. 7. Vertical view of nest in hummock behind tree and old stump. Nest of dry fine grass; probably Sorex. Sadler's woods.

hunting for food they seemed to depend entirely on their sense of smell, and when thus prospecting they wriggled their long pink snouts continuously and inserted them into every nook and crevice. They appeared to use their eyes merely in avoiding well lighted situations."

Our own data on bait "perception" are shown in Table 8 and Plate 2, and probably represent a measure of the sense of smell as applied to the particular baits used. The animal "chose" bacon, with peanut a close second choice, in three out of five seasons, and gave perception values of a little above 30 for four seasons. The constant use of the animal's nose, as mentioned above, seems to indicate that it has an acute olfactory sense.

Several authors have mentioned the disposition of Blarina, and it is described as being a pugnacious animal. Seton ('09) speaks of it as "unsociable to the point of ferocity". Shull ('07) and others have experimented by placing a Blarina and a mouse or a vole together in a cage. The Blarina usually killed the other animal by biting it in the parietal region of the skull. Kirk ('21) records a case where a weasel avoided a Blarina that was in a trap.

To what extent these shrews pair is a difficult question to determine. Seton says that "they pair but the male abandons the nest for a time on the arrival of the young." Hamilton ('29, p. 129), also, says that "there is little doubt that Blarina pairs, and if not for a life union, it is certain they are found together in periods other than the breeding season." Analysis of our own data (Table 25) threw but little light on this question. The trapping, as already noted, was done during the middle of the summer and not in the breeding season. Occasionally a male and a female would be taken together on the same day, and at other times two or more males or females would be taken close together. The data were carefully checked and every case tallied, in which two or more members of the same species were taken on the same unit of 99 traps on the same day. Table 25 shows the results for seven species, for the last four seasons (1931–34). It will be noted that for Blarina there are 32 instances where a male and a female were taken together while in 15 instances two males were taken, and in 14 instances, two females. This is approximately a 2–1–1 ratio. Such a ratio would mean that two of the same sex were as likely to be together as two of the opposite sex, and indicates that probably companionship is a mere matter of chance. Hence we conclude that there is practically no tendency for the opposite sexes to be together during the summer months. It is worthy of note that, as shown in Table 25, not more than three Blarina were taken on one group of traps in one day. Seton says of these short-tailed shrews that they are "neither sociable nor gregarious". Our data seem to indicate that at most they may be found together in small groups only.

Some authors (Klugh, Seton, and others) agree that Blarina is active at all times of day and night. Brooks ('08) says that it is but "little less diurnal than nocturnal". In the field, during the present studies, this animal was seen scurrying along in the burrows both in morning and afternoon, and it was trapped in the afternoon as well as at night.

The voice of the shrew may sometimes be heard after dark. The following note was written by Mr. Pearce after spending the night of August 21st at the

camp at St. Mary's Pond: "The caged Blarina wakened me in the middle of the night with its high-pitched twittering cry. It paused for a moment, and somewhere close by an answer came from another shrew. This cry came from a point about fifteen feet from where I lay. When it stopped, another cry from the other side of the cages was heard. The Blarina in the cage joined in. When these cries ceased, I heard the sound of a third individual, quite faint, as though at some distance. Then these sounds were heard no more."

The voice of the shrew may be described as a rather high-pitched, twittering whistle. Our caged specimen would emit the sound whenever we blew in its face, throwing its head back and opening its mouth wide with each call. Klugh ('21) characterizes the voice as "a continual rather musical chirping squeak". Our own observations indicate that it is not a continuous sound, and more of a whistle than a squeak.

Hamilton ('31, p. 99) makes the observation that they are "fairly sound sleepers".

The population of Blarina per acre in certain areas has been variously estimated by different authors. Shull ('07) has placed it at four per acre, while Hamilton ('31, p. 99) gives an estimate of four pair per acre, and cites an instance of 19 on ⅗ of an acre. Seton ('09) estimated fifty Blarina per acre in favorable territory. As might be expected in a quantitative study of various habitats, our own results indicated varying numbers per acre. As indicated in Table 17, estimates for various localities near Brewerton ranged from 8 per acre in the tall weeds along Little Bay Creek, an area where Zapus was numerically dominant, to 104 per acre in tangled weeds and vetch at Big Bay Point. At St. Mary's Pond, as summarized in Table 16, the estimates were 20 per acre in dry woods and 26 in moist woods. At Constantia estimates were 42 per acre in dry woods, 44 in moist woods, and 23 per acre in meadow. The Marcellus section showed similar numbers of 28, 37, and 34 per acre in these 3 types of habitat. At Conquest, in 1934, the species was markedly less abundant (an estimated 14 per acre in dry woods, 5 in moist woods and 11 in meadow). For other habitats we note from Table 16 that in sedge marsh and sweet flag marsh, Blarina is scarce (4 per acre) while in cedar-meadow, woods-meadow and dogwood, values run from 23 to 38. All these estimates are in general higher than the estimates of Hamilton and Shull, and lower than Seton's estimate of 50 per acre. Such studies are, of course, chiefly of value when the abundance of other small animals is considered in relation to the abundance of Blarina, a topic discussed elsewhere in this paper. Doubtless the abundance varies from one season to another in the same locality, following to some extent a cycle of abundance.

The home range of a Blarina is estimated by Hamilton ('31, p. 98) as being about one acre in extent. He says that "the ranges of two pairs of individuals must overlap at all times". In the present studies we have not been able to determine the individual range. There is presented, however, a study of the "wandering tendency" of the animal, and, as discussed elsewhere, the concept of wandering tendency involves size of range, the rate of movement through the range and the "pioneering" tendency which leads an animal to invade a trapped-out area. It varies with the habitat, species and sex. Tables 10 and 11 summarize these wandering tendency studies. In 1931 the Blarina males showed a higher wan-

dering tendency than did the females, but in the three other seasons the females showed the higher index. In Table 11, where the wandering tendency is considered with reference to habitats rather than to seasons, we note that the females always show a higher wandering tendency and that this is in three out of four habitats inversely proportional to the relative abundance of the sex: that is, the higher the wandering tendency of a sex, the lower the number of individuals of that sex caught in the traps. The only exception is in the moist woods habitat, where the sexes are about equal in numbers and where both show about the same wandering tendency. In seeking a reason for this we are inclined to believe that it indicates that the males in midsummer (between breeding seasons, probably) have a tendency to occupy their home territories and to keep the females out of their immediate neighborhood. However, when the males are taken out during the first three days of trapping, then the females wander into the vacated zone and yield a good late catch of individuals, giving, therefore, a high wandering tendency value for females.

The home range at certain seasons, at least as regards the females, centers about the nest. As before mentioned, Seton ('09) thinks that the male leaves the female while the young are in the nest. Nests of Blarina have been found and described by several authors, previously quoted. During the study at Brewerton we found three nests which were undoubtedly those of Blarina, although they were unoccupied at the time. They resembled the nests described by other authors and were in a section of woods where Blarina was the numerically dominant small mammal. Burrows leading to these nests were proved to be occupied and used by Blarina. The first of these nests was found in Hoyt's woods, near Little Bay Creek. A thread bait experiment late in July indicated the probability that a nest would be found in the center of a clump of basswoods. Twelve tree trunks of various sizes surrounded a mound of peat-like material about a foot high and two by four feet in lateral dimensions. (Plate 5, fig. 2). Burrows led to this clump of trees from three directions. Thread baits were being carried toward this clump from a distance of thirty feet, in one direction.

This shallow mound of peat was carefully excavated with a knife and a large spoon. Just below the surface a number of burrows made an interlacing network among the tree roots, with here and there a channel leading down to deeper levels. Below the upper series of channels lay a considerable thickness of peat which contained few burrows. Then, in the center of the mound and at about the level of the adjacent ground surface, the nest was found. Near by, one offset chamber about two and a half inches across was encountered along one of the channels. The floor soil of this chamber was black. Probably this was an old excrement-chamber. The nest itself was unoccupied and consisted of a hatful of rather large dry pieces of leaves. Shull ('07) considers a nest made of coarse materials, "never shredded or torn", as characteristic of Blarina in contrast with nests of Microtus, where the material is of finer texture. Upon careful removal the material in the present instance was found to have filled a shallow saucer-like depression in the dry soil. This depression was perhaps an inch deep and five inches wide. Six burrows entered it from the sides, two of which were connected by a furrow across the bottom of the depression.

A likely looking hummock (formerly an old stump), located near the one just described, was examined, and a nest was found near its center. (Plate 5, fig. 1). This hummock was in an open space in the woods. Two or three burrows led toward it, and several holes were to be seen in its sides. On excavation this hummock was found to be composed mainly of the same peaty material as found in the one first mentioned. And just below the surface was a similar network of runways in the moss, with here and there a burrow leading almost vertically downward. The nest, consisting of a double handful of dry leaf material, with a slight depression in the top, was found a few inches below the surface. A burrow encircled the nest near the bottom and was reached by the burrows, before mentioned, which led down from the sub-surface burrows. The leaves in this case were mixed with fine, dry rootlets. The nest showed no signs of having been recently occupied. Its general level was that of the ground surface.

Another nest that very probably belonged to Blarina was found at Sadler's swamp, near Brewerton, by digging into a hummock surrounding an old stump. (Plate 5, fig. 3; and Fig. 19). It consisted of a similar ball of dry leaves filling a depression. In this case, however, there seemed to be but one entrance.

Breeding data.—In the field notebook were recorded all instances of pregnant and lactating females taken, and of enlarged testes indicating sexual activity in the males. These notations were made at the time when the specimens were taken from the traps. All obvious pregnancies were recorded during the first two seasons; and during the following seasons ('32, '33, '34) every female specimen caught in the traps was opened and examined for pregnancy. Table 26 summarizes the results for Blarina for five seasons.

The rather limited number of records in this table indicate pregnancies more numerous in June, and lactating females more frequent later in the summer. Considering the large number of Blarina caught during this study, the breeding records are rather few. However, they are in general agreement with the statement of Hamilton ('29, p. 129) who says, regarding this species, that "two litters are produced annually, one in spring and another in late summer". Seton ('09) says that "the first pairing season occurs in early April"; and Merriam ('95), that two or three litters are born each season. Our own trapping was done in the three summer months, but mainly in July, and accordingly fell between the two breeding seasons mentioned. Perhaps this is also the reason why the nests were found unoccupied at the time. According to Hamilton (l. c., p. 128), the first litter of spring-young is born about mid-April, and the last litter in the latter part of May (at Ithaca, N. Y.). He says that the gestation period is 21 days or longer, and that the young leave the nest at 15 days of age, when they have a length of 73 mm. He believes that they are weaned when about 91 mm. long. None of our specimens was as small as this. Hamilton reports, further, that no specimens showed signs of sexual activity in July or August. Our own data would seem to indicate some instances of sexual activity in these months, among the large number caught.

The number of embryos found in our specimens is given in Table 26. The average was 5.6. Hamilton ('29, p. 134) found an average of seven, for twenty-nine pregnant individuals. Seton ('09) presents two records of five embryos each.

Sex ratios.—Data on the sex ratio are presented in Tables 13 and 14. These are based on field determinations of the sex of the specimens, internal examinations being made in doubtful cases. (In a few instances the record of the sex was inadvertently omitted, as indicated in the table.) As appears from the tables, the sex ratio varied in different habitats. In dry woods, cedar-meadow and sedge marsh, the males were generally more numerous, averaging about 66% in the

Table 26. Breeding Habits of Blarina, Including Records for Five Seasons.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
	June 13, 1933.....	6	June 7, 1933
	June 15, 1933.....	6	
	June 19, 1933.....	5	June 20, 1933
June 24, 1932.....	.....	.....	
	June 25, 1933.....	12	June 25, 1932–2
	June 26, 1933.....	6	June 26, 1930
			June 26, 1931
June 27, 1932.....	.....	.....	
June 30, 1932.....	June 30, 1933.....	5	
	June 30, 1934.....	6	July 1, 1932
July 6, 1934.....	.....	.....	July 2, 1934
	July 6, 1933.....	5	July 3, 1934
July 10, 1932–2.....	.....	.....	July 8, 1930
	July 12, 1934.....	5	July 10, 1934
	July 15, 1930.....	5	July 12, 1933
			July 12, 1934
	July 21, 1934.....	4	July 13, 1934
	July 22, 1930.....	4	July 14, 1932
			July 14, 1934
	July 24, 1934.....	5	July 15, 1934
Aug. 7, 1932.....	.....	.....	July 17, 1931
Aug. 9, 1932.....	Aug. 9, 1933.....	5	July 17, 1932
Aug. 10, 1932.....	.....	.....	July 19, 1930
Aug. 13, 1932.....	.....	.....	July 20, 1931
			July 24, 1930
			July 30, 1932
			July 31, 1932
			Aug. 13, 1930
			Aug. 19, 1933

dry woods alone, while in the moist woods, in three out of four seasons, the males were less numerous than the females, so that they averaged about 48% of the catch for four seasons. In meadow the males were slightly more numerous. These figures are, of course, based on the total catch, both early and late. They would indicate, however, that sex ratios in random trapping should be interpreted in terms of habitat. As shown in Table 12, out of our total catch of 438 specimens of Blarina that were definitely determined as to sex, we found 240 males to 198 females. Hamilton ('29), in his studies, found more than twice as many males as females.

Hibernation.—Writers (Seton, '09, Hamilton, '29, et al.) agree that Blarina does not hibernate, and Rhoades ('03) says that young are born at all seasons of the year, though less frequently in winter. Jackson ('20) found this

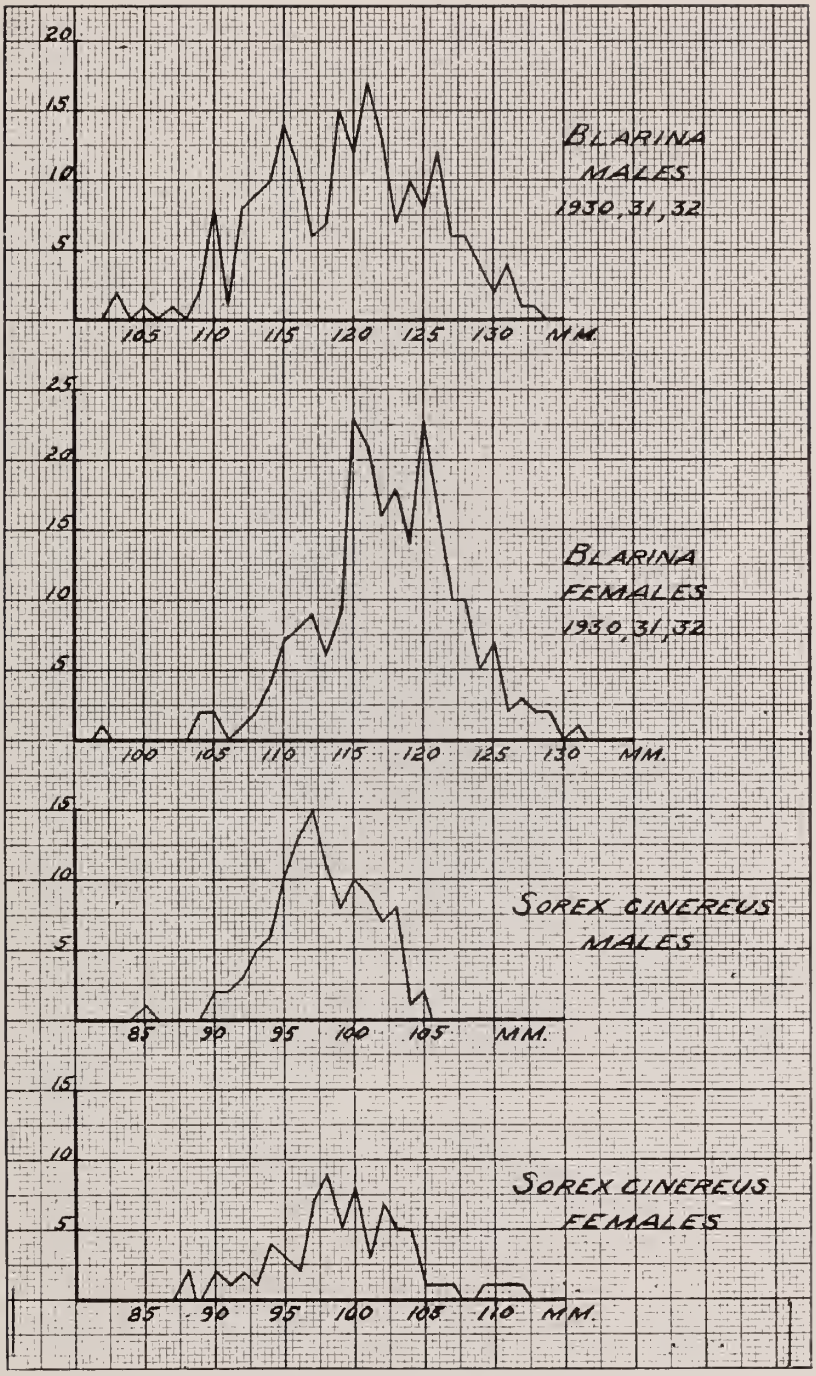


Plate 6. Showing, for each group, field measurements of total lengths in millimeters and the number of individuals measured.

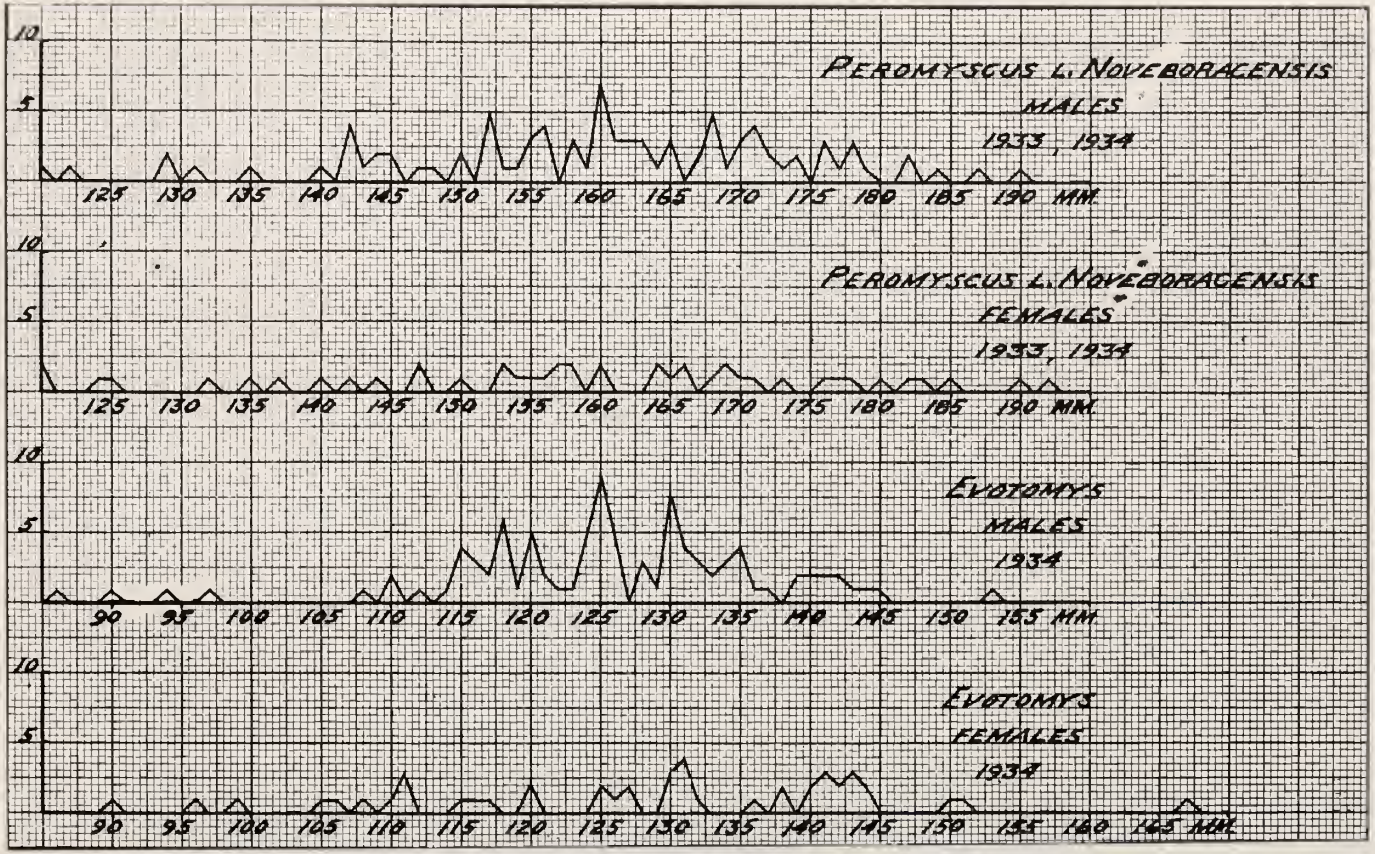


Plate 7. Showing, for each group, field measurements of total lengths in millimeters, and the number of individuals measured.

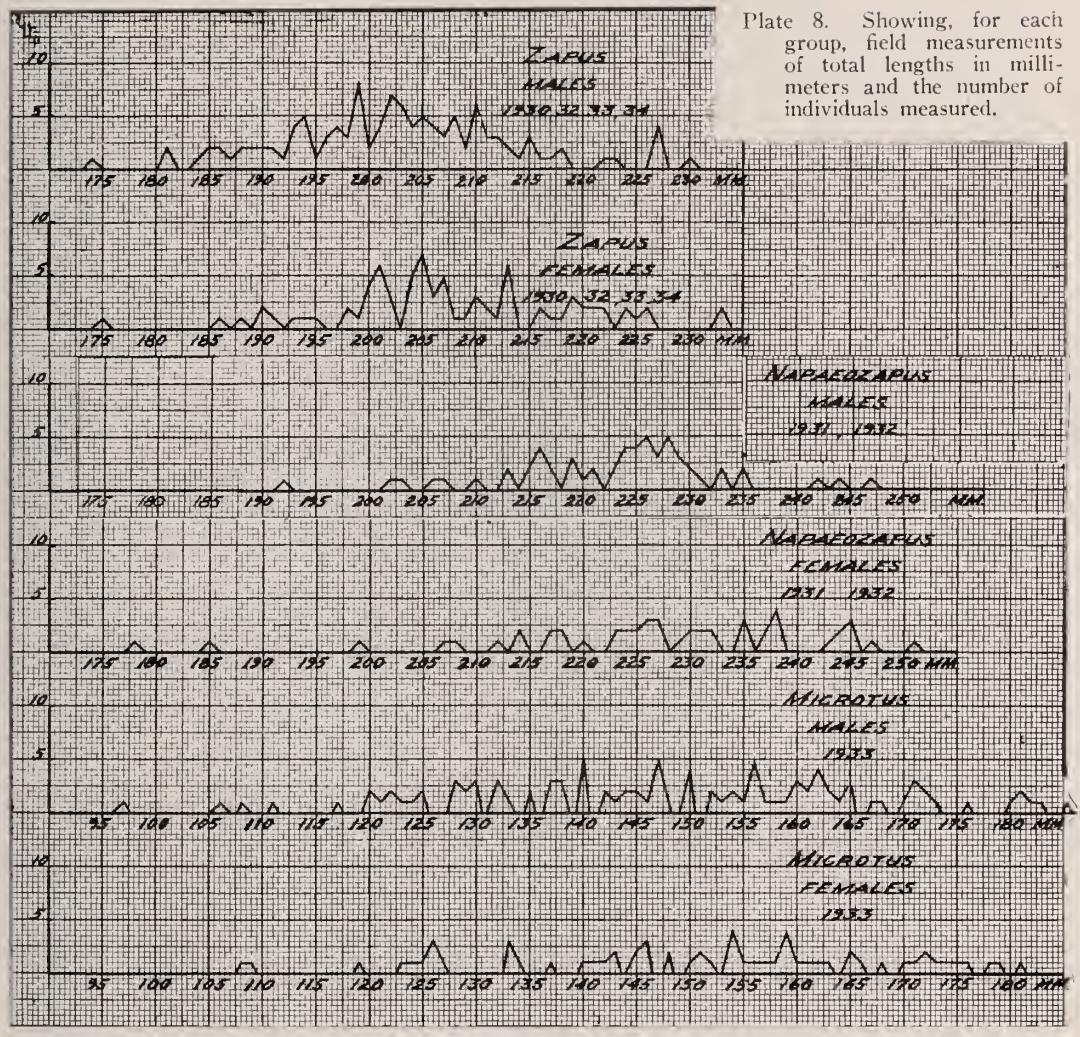


Plate 8. Showing, for each group, field measurements of total lengths in millimeters and the number of individuals measured.

species among others on an island in a Wisconsin lake, and explained its presence there by assuming that it had crossed from the mainland on the ice. Merriam ('84) says that "it scampers about on the snow during the severest weather."

Size variation.—With respect to size, Blarina showed less variation than did most of the other small mammals taken in the present study. Field measurements of Blarina for three seasons (Table 35) gave a mean length for males of 119.5, plus or minus .283 mm., based on 198 specimens. For females the mean length was 117.4, plus or minus .225 mm., based on 224 specimens. These results are lower than Seton's estimate of 127 mm., and higher than Goodwin's ('24) average of 111 mm. for six specimens of Blarina from the Gaspe Peninsula, Quebec. Anthony ('28) says that the sexes are of equal size (five inches or 126 mm.). Dice ('27) gives measurements of 106–135 mm., which agree with the range of our own measurements as shown in Plate 6.

Standard deviation.—The standard deviation for total lengths of Blarina was 5.92, plus or minus .200 for males; 5.05, plus or minus .161 for females. As noted elsewhere, this was the lowest standard deviation shown by any of the species studied, except Sorex. The explanation may in part lie in the fact that the trapping was done in midsummer, between the two breeding seasons, when the spring litters may already have reached adult size. Catches of other species no doubt included many immatures, and for this reason showed a higher variability.

Blarina is said to molt without regard to season (Hamilton, '31). Our own records show one male in the molt, July 10, 1932.

The abundance of Blarina and its occurrence in various habitats make it a very interesting little mammal ecologically. Although apparently very sensitive and wary, it is nevertheless highly adaptable. Its possible relation to the other small mammals in its habitats is a question which needs further study. There is no doubt that Blarina can and does on occasion kill and eat other small mammals. Also, according to Brooks ('08), it probably robs birds' nests, and it would not be surprising to find that it is an important factor in the lives of some birds that nest on the ground. Whether it would invade a nest above the ground,—as in a low bush,—is doubtful. Hamilton ('31) says that it rarely jumps; and Klugh ('21), that these shrews are "not at all expert climbers". According to Seton ('09), they are "incapable of climbing or running fast". While from the present study we are inclined to differ somewhat on the question of speed, we agree that the animal shows little disposition to climb. But it seems probable that Blarina may at least invade the nests of small birds, as well as the nests of various small mammals, also, and at times may kill the young if not the adult inmates.

One may wonder if in any given small-mammal community Blarina might represent a climax species. For example, at Hoyt's woods, as previously stated, we found Blarina representing an estimated 84% of the small-mammal community in the moist woods habitat. Perhaps this woods was approaching a climax condition in this respect. In contrast, at St. Mary's Pond, Blarina was found to constitute only 22% to 24% of the small-mammal population (Table 19), and in moist woods at Conquest, only 4%. The thought occurs that possibly there is a succession in the small-mammal population, perhaps recurring in cycles, and with Blarina tending to achieve dominance until some disease, parasite, dry season or other cause

(or combination of causes) in turn checks it and gives others a chance to start the cycle anew. Enders ('30), in Ohio, found that occasionally in woods Blarina was more numerous than Peromyscus, and at other times less numerous. He considered differences in population as due to the "occurrence of minor habitats within the provinces". The present writer is of the opinion, however, that a succession principle is also to be considered. Further research is here needed, but in this connection Adams ('09) and other authors have mentioned an apparent season of mortality among the short-tailed shrews in the autumn months. This has been variously explained. Adams ('09) attributes it to old age, basing his conclusion on the fact that all his immature specimens were taken later than December. He states that old age is reached in about 13 or 14 months. Possibly late summer drought may be a factor in the mortality of these animals, since they are known to drink a considerable amount of water. But Hamilton ('31) finds no such autumn mortality. Harper ('29) found Blarina less common in the Adirondacks in 1926 than in 1925. He says that "no other Adirondack mammal showed such striking fluctuation in numbers between 1925 and 1926 as did Blarina." He suggests as causes a failure of the beechnut crop and a scarcity of mice during 1926.

SOREX CINEREUS AND S. FUMEUS

Specimens of Sorex were taken on the trap lines in at least some of the habitats in all the areas studied. At Brewerton they were taken in two localities: a roadside in Big Bay Swamp yielded a few, and a swamp near Long Point yielded several. All these were identified as *Sorex cinereus*. During the summer at St. Mary's Pond, and also at Constantia, the genus was fairly well represented, but later identification of prepared skins proved that we had taken two species, *Sorex cinereus cinereus* and *Sorex fumeus fumeus*. Unfortunately the two forms were not recognized as distinct in the field notes for the first two seasons, and therefore they can be discussed only generically for these periods. In 1933, at Marcellus, and in 1934, at Conquest, careful attention was given to all specimens of Sorex taken, but in these localities all proved to be *S. cinereus*.

At Brewerton representatives of Sorex apparently were entirely absent from most of the habitats examined; but they were found in Sadler swamp, near Long Point, to the estimated number of about 63 per acre, in a relatively small area studied (Table 17). At St. Mary's Pond the two species (*cinereus* and *fumeus*) were encountered in the woodland habitats, and their combined population was estimated at 13 per acre in dry woods and 16 per acre in moist woods (Table 16). At Constantia the estimate was 11 per acre in dry woods and 15 per acre in moist woods. At Marcellus, *cinereus* was found in all the habitats except dry woods. The moist woods showed a comparatively high estimate of 30 per acre. At Conquest, an estimated 13 *cinereus* per acre was found in moist woods. These figures and others will be found summarized in Table 16. It is noteworthy that the estimates for Sorex (as a group) in woods habitats are usually around 11 or more per acre if this genus is represented at all. An exception was at Marcellus, where the moist woods population of *S. cinereus* proved to be as high as 30 per acre. This may, perhaps, easily be explained by the nearness of a cedar-meadow habitat, which was well populated with Sorex—an estimated 53

per acre. Cedar was present in the moist woods at Marcellus, and cedar growth seemed to be in some way associated with the abundance of Sorex, for it was found in all the best Sorex localities noted in these studies.

The catches ('33 and '34) outside of woodland, indicated that Sorex finds most favorable conditions in "mixed" habitats of trees and meadows, with many old stumps and logs. Population estimates at Marcellus for cedar-meadow (Table 16) showed 53 per acre; for woods-meadow, 26; for dogwood, 28; for sweet flag, 23; and for meadow and marsh, from 2 to 18.

Studies of community percent (summarized in Table 19) show similar results. Sorex represents usually 12% to 15% of the woods community small-mammal population, where it occurs, the maximum from our estimates being 29% in moist woods, in 1933. In mixtures of trees and meadow, percentages are roughly from 20 to 40, but in weed-meadow alone they run low (0% to 14%).

The fact that values for the woods habitat are fairly consistent from season to season, in different localities, makes it seem probable that no distinct cycle of abundance occurs in these situations, at least within shorter periods.

From Table 21 we note that Sorex "prefers" moist woods rather than dry woods or meadow, and apparently it chooses any of the other habitats listed in preference to meadow.

Studies of habitat "selection" ratios are summarized in Tables 21 and 22. In Table 22 the data are organized for each sex and we note that in every case males and females both show a habitat "selection" in the same direction, a fact which does not apply to all the other forms studied. Sex ratios, as indicated in Table 13, were variable, but roughly the sexes were approximately equal in all habitats except meadow, woods-meadow and marsh, where the males predominated.

Jackson ('28) describes the characteristic habitats of long-tailed shrews as "moist situations with abundance of vegetation, such as mossy and grassy banks along streams, meadows, sphagnum bogs and damp woods, particularly of coniferous trees." This general statement is, of course, designed to cover the entire genus. In the present studies Sorex was found typically in woods with swampy surroundings, and containing numerous stumps and logs. The wooded edge of the quaking bog around St. Mary's Pond was obviously favorable, as was also the cedar woods near Marcellus and the woods at Sadler's farm, near Brewerton; and the same may be said of areas that contained a mixed growth of cedar and rank meadow grass.

Sorex seems to show a "preference" for cavities and holes around mossy stumps. Occasionally small burrows were found in such situations, but in general it would seem that the two species here concerned are not active burrow-makers. In studies of place "perception" (Table 8 and Plate 3) it was noted that Sorex was more frequently trapped in "burrow" sets than in "cover" or "open" sets. Komarek ('32) records observations on *S. cinereus,* in which he says of the animal that "He did not follow any evident runways or tunnels, but seemed to go wherever fancy led him." At Marcellus, in very thick weed and grass and brush growth, Sorex was caught most often in "cover" sets, rather than in burrows, reaching a place ratio as high as 69% in 1933 (Table 8). At Conquest it was taken only a little more frequently in burrows than in open or "cover". Seton ('09, p. 1096)

characterizes *S. cinereus* as "but slightly subterranean and is incapable of climbing", and "never found far from water and yet it is not in the least aquatic."

There is apparent agreement among writers on the subject that in Sorex there is a keen sense of smell, and the present studies on bait "perception" (Table 8 and Plate 2) tend to support this view. The bait "perception" values for five seasons were, respectively, 62, 70, 32, 80 and 43, and with reference to the baits used,—bacon, peanut and raisin baits,—Sorex seemed to show a more distinct "choice" than did any other of the small mammals studied (Plate 2). Strangely enough, its "choice" among the three baits was peanuts. This was rather unexpected since the Sorex group is largely insectivorous. Jackson ('28), however, states that these animals are "chiefly insectivorous, but will eat other flesh and occasionally vegetable matter". He mentions that in captivity they have been known "to eat their own weight in meat on an average of once every three hours". Seton ('09), who says their food is chiefly "insects and worms", likewise stresses the enormous appetite of these shrews. Hamilton ('30), on the basis of stomach contents, found the following items in the diet of *S. cinereus*: insects, 65.3%; vertebrates, 7.1%; centipedes, 6.8%; worms, 4.3%; mollusks, 1.2%; vegetation, 1.1%; arachnids, .9%; and for *S. fumeus*: insects, 70.4%; centipedes, 4.9%; salamanders, 3.6%; plants, 3.6%; worms, 3.4%; sowbugs, 2.8%. In view of these facts it is rather surprising to find Sorex being caught continually on peanut baits. Possibly this is due to some quality of the oil in peanuts. This bait, too, seems particularly subject to the depredations of insects and snails.

Disposition.—No specimens of Sorex were kept in cages during this study, and no observations were made on disposition, in this group. Jackson ('28), however, describes these animals as "active, vicious, voracious little imps of the animal world." Seton ('09) says they are "unsociable to the point of ferocity." In Table 25 we note that a male and a female *Sorex cinereus* were taken in traps, set near together, 19 different times during the course of the trapping, while two males were taken thus 21 times, and two females 3 times, perhaps indicating more sociability among males than among the females in the summer months. Groups of three, four and five individuals were taken near each other on 11 occasions. During the seasons 1933 and 1934, 58% of the Sorex specimens were caught singly.

Home range.—With regard to the home range in this group, but little information is available. Seton (l. c.) cites Nelson's notes from the Yukon valley, which indicate that *Sorex cinereus* may travel a mile or two from home; and also may migrate at the beginning of winter. Our own studies of the wandering tendency in the Sorex group in the territory in question (Tables 10 and 11) give results that are conflicting and difficult of interpretation.

Most authors agree that the shrews are continually active. Seton (l. c.), however, says they "run by day as well as by night", while Jackson ('28) considers them "largely nocturnal"; but they agree that the animal does not hibernate or store food.

Nests.—Search at Sadler's woods (south of Brewerton) revealed several nests which were considered to be those of *Sorex cinereus*. They agree with

meager published descriptions of the nests of this form, and were found in a habitat which yielded numerous specimens of the species on the trap lines. But none of the nests was occupied when found. One was in an old hollow log (Plate 5, fig. 5). A small round burrow, hardly large enough for any other mammal except Sorex, led down to a small ball of fine grass in the hollow center of the log, resting on a mass of tangled rootlets. Three other similar nests were found in old logs, or stump hummocks, the general locations of which are shown (Plate 5, figs. 4, 6 and 7). Figure 20 gives a general idea of the fine shredding of the nest material. All the nests were small,—four or five inches across.

Sex ratios, etc.—Sex ratios for Sorex showed a certain agreement in similar habitats, as indicated in Table 13. In moist woods, for three seasons, a little more than 50% of the specimens taken were found to be males; in meadow, over 60% were males. Other habitats always showed some preponderance of males, except dry woods and dogwood patches, where females were more numerous.

Our small number of records on pregnancies, embryos, etc., are set forth in Table 27, where observations for three seasons on *Sorex cinereus* are summarized. Pregnancies were few in our catches of Sorex and were mostly found during the latter part of the season. Seven records gave an average of six embryos to the litter.

Measurements.—Field measurements of 186 specimens of *S. cinereus,* the catch for three seasons (Table 35), gave a mean length of 97.8 mm., plus or minus .228 mm., for the males; and 99.4 mm., plus or minus .389 mm., for the females. The standard deviation was very low (3.60 mm., plus or minus .175 mm., for males; and 4.93 mm., plus or minus .275 mm., for females). Probably most of the specimens were adults, which would account for the low figures for the standard deviation.

Measurements of 16 specimens of *Sorex fumeus* (identified by A. H. Howell) gave total lengths ranging from 109 mm. to 123 mm. for 9 males; and from 111 mm. to 126 mm. for 7 females.

Social groups.—Table 25 shows that a few groups of 4 and 5 individuals were taken fairly near one another. These catches do not necessarily mean that the animals were associating together at the time they were trapped. More likely they contain a suggestion as to the size of the home range. It is significant, perhaps, that Blarina shows no catches of as many as 4 or 5 individuals on the same trap line in one night, while Sorex shows five such groups. The records of the instances in which two individuals of Sorex were caught at one time (i. e., in a 24-hour period), include 19 instances of one male and one female thus taken, 21 of two males, and only 3 of two females,—indicating possibly that females of these Sorex species do not tolerate the presence of other females of their own kind in their neighborhood during the summer months, but are agreeable to the presence of males. The scant data on catches of 3 and 4 individuals also tend to support this view.

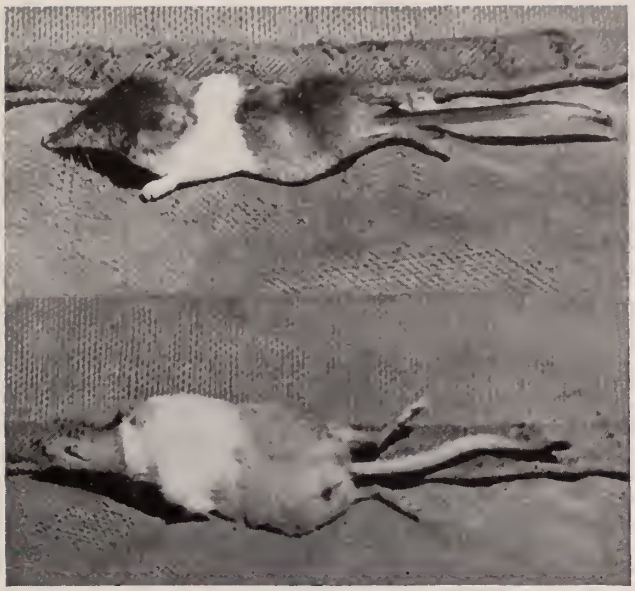


Fig. 21. Unusual white banded Sorex caught at Marcellus, August 5, 1933. Photograph by John Pearce.

Fig. 22. An old Evotomys nest (near pencil point) in opened hummock. Lincoln's woods, Conquest. August 1, 1934.

TABLE 27. BREEDING HABITS OF *Sorex C. Cinereus*, INCLUDING RECORDS FOR THREE SEASONS.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
	June 19, 1933.....	5	
			June 21, 1933
			June 23, 1933
			June 26, 1933
			June 26, 1933
			June 26, 1933
	July 4, 1933.....	6	
			July 5, 1933
			July 8, 1933
			July 12, 1933
	July 13, 1933.....	7	
July 17, 1934.....	.....	.....	
	July 28, 1933.....	4	
	July 30, 1934.....	7	
	Aug. 1, 1934.....	6	
			Aug. 5, 1934
			Aug. 7, 1934
	Aug. 14, 1930.....	?	
	Aug. 14, 1930.....	?	
Aug. 16, 1934.....	Aug. 16, 1934.....	5	

PEROMYSCUS LEUCOPUS NOVEBORACENSIS AND P. MANICULATUS GRACILIS

White-footed mice were taken in the woods in all localities studied. As indicated in Table 19, these mice (of two species) were the most abundant of the small mammals in the dry woods community, in three of the four seasons (being outnumbered in 1932 by Blarina). In the moist woods, too, we note that in the season of 1931 Peromyscus was the numerically dominant mammal. Various other workers have found Peromyscus the most numerous form, also, in woodland sections in other states. (Anthony, '28, and Ender, '30, in Ohio; M. S. Johnson, '26, and Wood, '10, in Illinois.)

As indicated in several of the tables in this paper, Peromyscus is primarily a woods animal, but occasionally is taken in the meadow habitat (at Marcellus, 1933); and frequently it is abundant in "mixed" habitats of woods and meadow. As indicated in Table 16, the estimated population per acre was found to vary in the dry woods from 19 to 33. It varied also in moist woods. In 1931 and 1932 we encountered two species, *P. leucopus noveboracensis* and *P. maniculatus gracilis,* but unfortunately did not at the time recognize the distinction, and therefore they were not listed separately in the field notes. The two species together, in the moist woods, gave population estimates of 30 and 14 per acre, for the two seasons in question. At Marcellus and Conquest, with the form here found definitely identified as *Peromyscus leucopus noveboracensis,* the populations in the moist woods were 31 and 30 per acre, respectively, for the two seasons mentioned. Meadow and marsh habitats yielded only low catches of Peromyscus, while cedar-meadow, woods-meadow and dogwood gave fairly high ones. M. S. Johnson ('26) has mentioned taking *Peromyscus l. noveboracensis* a short distance from woods, in corn fields, for example.

Referring to habitat "selection" ratios in Table 21, we note that the white-footed mice were slightly more numerous in dry woods than in moist woods. Records for 1934 are not included, since the dry woods then concerned was several miles distant from the moist woods. From Table 22, where the sexes are treated separately, we note that the two are not always equally numerous in the same type of woods. Males may be more numerous in dry woods, females in moist woods, or vice versa.

Habitat "perception" also seems to vary with different years, as shown in Table 23; but as indicated in Table 24, the habitat "perception" of females in woods was always higher than that of the males, the females being, as it were, two to five times as sensitive to the "difference" between dry woods and moist woods as were the males.

As to its place relations within the habitat, the studies on place "perception", summarized in Table 8 and Plate 3, indicate that the white-footed mouse is found more often in open and in "cover" than in burrows; and place "perception" values for four seasons were remarkably uniform, ranging from 29 to 33. Osgood ('09) says that "they (white-footed mice) do not form beaten runways", but "freely use such runways made by other rodents". Stone and Cram ('10) tell of an abandoned woodchuck burrow that was used as a winter home by several families of deer-mice. Seton ('20) mentions that a white-footed mouse, on being released from a trap, ran about and squatted several times before seeming to find a burrow by chance; while meadow mice under similar conditions actively sought a burrow.

Peromyscus is chiefly a nocturnal mammal, and no doubt has keen senses of hearing and sight. However, studies of bait "perception" as summarized in Table 8 and Plate 2, point to a rather low sense of smell as compared with some other small mammals. Its "perception" values run from 10 to 17, in four seasons, with one value of 38 in 1930. The "selection" of the "foreign" baits used was highly variable: bacon, peanut and raisin each being most frequently taken ("preferred") in one or another locality.

Peromyscus is also chiefly a vegetarian. A few of the things eaten by our caged individuals will be listed beyond in the account of Evotomys, since our study included a comparison of these two species. Cogshall ('28) has listed 52 kinds of seeds and fruits, the bark and buds of 15 different trees and shrubs, and 20 species of insects, besides other animal matter eaten by captive Peromyscus.

As regards social tendencies in Peromyscus, the records for the summer months, summarized in Table 25, show that in our traps a male and a female were taken near together in the same night, on 22 different occasions. Two males were similarly taken on 11 occasions and two females on 3 occasions. This may indicate an unsociable nature on the part of females, at least during the summer season. Mixed groups of three were taken on 3 occasions, and a group of three males was taken once; also a group of three females, once. In one day, four males and one female were taken in one trap unit. Larger groups of individuals are noticeably absent from these catches.

Definite information about the home range of Peromyscus seems to be scant. Authors usually suppose that the deer-mouse has a range probably about one

hundred to three hundred feet across. Its homing instinct has been the subject of some study. M. S. Johnson ('26) records cases where Peromyscus returned 150 yards in one night; and the Muries ('31 and '32) have lately reported instances where members of this same genus returned over a distance of two miles to their home locality. Three individuals were found by these authors, a year later, within 75 yards of the place where they were caught the first time.

During the season of 1934, in the present connection, a study of homing instinct and home range was attempted, at Conquest, N. Y., by using live-traps. On a drumlin here situated, and covered with maple woods, we caught and released a number of individuals of the form *Peromyscus l. noveboracensis,* and found that several of these, released at a distance of 100 yards, returned to practically the same locality where they were first taken. In an extensive tract of moist woods there was laid out a quadrat containing 16 live-traps, spaced in squares, and 35 feet apart. Specimens of *Peromyscus l. noveboracensis* were taken here, and each individual was marked by means of an ear punch and then released at the same spot. The trap was left closed for 24 hours, and then reset to await results.

It will be noted from Table 28 that for Peromyscus, 3 females and 4 males were included in this experiment, and that all the females were recaught, but only two of the males. The recaptured individuals were each retaken in the same trap in which they had been taken previously. And one of the females was caught 11 times in this same quadrat. This would indicate a small home range for these individuals. The failure to retake half of the males is in line with our results on the wandering tendency of the sexes discussed in the following paragraph. As noted in Table 28, the males here showed a wandering tendency value of 37 as compared with 14 for the females.

Table 28. Summary of Live-Trap Captures at Conquest, N. Y., 1934.

	Peromyscus		Evotomys	
	F.	M.	F.	M.
Number caught	3	4	16	10
Number marked	3	4	10	8
Percent recaught.....	100	50	60	87.5
Percent recovered at same place	100	50	30	37.5
Number of times recovered at same place.....	2, 1, 2	1, 2	1, 1, 1	2, 1, 2
Population per acre.....	11	19	21	37
Wandering tendency value.	14	37	49	67

Studies on the sex ratios are presented in Table 13, where total catches for all the seasons concerned are summarized by habitats. It is noteworthy that Peromyscus in all cases shows a preponderance of males, percentages varying from 51 to 100 and averaging 69. Fraleigh ('29) reports that near Indian Lake, N. Y., in 1925, a preponderance of males was found in Peromyscus. This would at first suggest that males are much more numerous than females. However, the study

of wandering tendency appears to throw a different light on the matter. Tables 10 and 11 summarize the results on the wandering tendency studies grouped in two different ways. It is noted that almost without exception the wandering tendency value of the males is higher than that of the females and is correlated with the higher catch. Probably as a result of this higher wandering tendency, the males (some coming from more distant parts) are taken in the traps more often than are the females, and thus the sex ratio would appear to show a preponderance of males. It is possible, furthermore, that the females are inclined to keep the males away from their own nesting localities, or home ranges; but after trapping has removed or reduced the female population the males are given a chance to invade the territory, are caught on the later trap-days and thus give a higher wandering tendency value. At least it seems evident that any study of sex ratios from trap-line data must take into consideration the factor of wandering tendency. Clearly the two are related.

Breeding habits.—Results on the breeding activities of *Peromyscus l. noveboracensis* are summarized in Table 29. Pregnancies were found throughout the season, which agrees with the observations of others. Osgood ('09) speaks of Peromyscus as being "extremely prolific", bearing 4 to 6 young in a litter and breeding throughout the year. Svihla ('32) estimated the number of litters as ten per year, and the average number of young per litter as 4.36, plus or minus .10. Wood ('10) says that "young are born at all times from January to October. It is likely that the same individual might produce three litters a year. The number in the litter is rather small, two to five, averaging less than four". Svihla ('32) estimated gestation to extend over a period varying from 22 to 37 days.

Results of the present study indicate more breeding activity during the summer months, for Peromyscus, than for any other small mammal here concerned, except Microtus. Pregnant and lactating females, and immature individuals, were found in all three of the summer months. Embryos ranged in number from 3 to 7, with an average of 4.7, which is only a little higher than Svihla's average mentioned above. In the present study the count was of embryos in the uterine horns rather than of young in the nest.

Measurements.—In Table 35 measurements are given for *Peromyscus l. noveboracensis* taken during the seasons 1933 and 1934. Males showed a mean length of 159.7 mm., plus or minus 1.014 mm.; and females, 158.4 mm., plus or minus 1.923 mm. Standard deviation was high (above 14 for males, above 18 for females), as would be expected in an animal breeding throughout the summer months and thus adding subadults to the trap-line catch.

EVOTOMYS GAPPERI GAPPERI

The red-backed mouse was not taken on the trap lines at Brewerton or at Marcellus, and at St. Mary's Pond and at Constantia it was taken only in small numbers. At Conquest, however, in an extensive area of moist woodland it was taken in considerable numbers.

Evotomys is here, evidently, strictly a woodland species. We note (in Table 16) that it was found both in dry and in moist woods, but not elsewhere. The status of the red-back with reference to other species in the areas concerned appeared variable. As shown in Table 19, in 1931 and 1932 the species represented an estimated 10% to 16% of the small-mammal community in the woods. At Conquest, in a large area of dense moist woods, the red-backed mouse was the

Table 29. Breeding Habits of *Peromyscus Leucopus Noveboracensis*, Including Records for the Seasons of 1933 and 1934.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
	June 9, 1933	3	
	June 12, 1933	5	June 12, 1933
	June 17, 1933	4	
	June 26, 1934	5	
			June 28, 1934
	June 29, 1933	?	
July 3, 1934	July 3, 1934	5	
	July 7, 1933	4	July 7, 1933
July 11, 1934			
July 12, 1934			
July 13, 1934			
July 15, 1934			
July 19, 1934			July 15, 1933
July 21, 1934			July 21, 1933
	July 22, 1934	4	
	July 25, 1933	4	
	July 25, 1934	6	
			July 26, 1933
	July 28, 1933	5	
	July 29, 1933	Early	
	July 31, 1933	3	
			Aug. 1, 1933
	Aug. 2, 1933	5	Aug. 2, 1933
	Aug. 3, 1933	4	
Aug 4, 1934			
	Aug. 5, 1933	5	
Aug. 7, 1934	Aug. 7, 1933	5	
Aug. 7, 1934	Aug. 7, 1934	5	
Aug. 7, 1934	Aug. 7, 1934	7	
	Aug. 9, 1934	6	
Aug. 13, 1934			
Aug. 13, 1934			
Aug. 16, 1934			

most abundant species, representing an estimated 51% of the small mammals, and a population per acre of 58.

As regards habitat "selection", the limited number of records in Table 21 indicates a "preference" for moist woods rather than for dry woods. However, from Table 22 it appears that the males are found in moist woods more frequently than are the females. But the data on this question are inadequate, for we found no dry woods and moist woods near enough together for satisfactory comparison. From Table 23 it would seem that habitat "perception" is low.

As indicated in Table 13, males were always in the majority in the trap-line catches, ranging from 66% to 91%. This is perhaps correlated with their wandering tendency as summarized in tables 10 and 11 and already discussed.

The place of Evotomys within the habitat is indicated in Table 8 and Plate 3. Evotomys is unique among the forms studied. It shows almost no place "perception" (2, 6, and 1 being the values obtained), the curve for each of the three seasons being almost a straight line. This means, possibly, that within its own home range Evotomys explores thoroughly every nook and cranny. It is found in burrows, under the "cover" and out in the open spots with about equal frequency. This is in marked contrast with other species. Peromyscus, for example, at Conquest (in the same woods in which we got our largest catches of Evotomys), showed a place perception value of 33.

As regards bait "perception", it would appear from Table 8 and Plate 2 that Evotomys has a keen sense of smell. Bait perception values for the three seasons were, respectively, 35, 44, and 32, with peanut the "preferred" bait in each case.

Seton ('09) says that Evotomys is "omnivorous, but shows little of the carnivorous propensity". Other authors seem to be of the same opinion. During the summer at St. Mary's Pond a few red-backs were kept in field cages, and various kinds of food were placed before them. The experiment was in the nature of a comparison of food habits of Peromyscus and Evotomys. Each day some different shrub or herb or other item of food gathered in the woods of their native habitat, was offered to these caged individuals, the same amount being put in each cage, and note taken of the extent to which they used it as food or nesting material. The animals were well fed and cared for in general, so that in no instance was an individual forced to eat a certain item of food because of hunger. Following is a summary of the results (Table 30).

Table 30. Experimental Feeding of Peromyscus sp. and *Evotomys gapperi* in Captivity.

Food	Peromyscus	Evotomys
Meadow rue	One ate a few leaves Two ate all	Ate stem and leaves
Ground hemlock	One ate none Two chewed stem and needles to a considerable extent	Ate none
Choke cherries	Ate all	Ate all
Jewel weed	Ate a little	Ate more
Clintonia leaves	Ate none	Nibbled some
Clintonia berries	Ate a few	Ate all
Prince's pine	Ate none	Ate none
Wintergreen	Ate none	Nibbled a little on both leaf and stem
Solomon's Seal	Nibbled small part of stem and one leaf	Entire stem and parts of several leaves eaten
Oat meal	One ate a small amount Two ate nearly all	One ate nearly all Two ate more than did Peromyscus
Green sticks of maple, striped maple and moosewood	Gnawed them all	Untouched
Moosewood leaves	Ate none	Nibbled a little
Witch hobble	Untouched	Ate all
Birch bark	Carried into cover	Carried into cover
Eggs (hard boiled)	Nibbled slightly	Nibbled slightly
Bread	Ate a little	Ate more
Acorn	Untouched	Nibbled a little
Cranberry plants	Ate a little	Ate more
Cranberries (last year's)	Ate out the centers	Ate all
Ferns ("fiddle heads")	Nibbled stem slightly	Ate stems; nibbled leaflets
Wild ginger	Untouched	Untouched
Raisins	Ate all	Ate none in two days
Water	Drank a little	Drank a great deal

Behavior.—Evotomys and Peromyscus.—The following extract from the field notes pertains to the behavior of the caged individuals: July 7. Cool and cloudy. Observations of caged animals at about 10:30 a. m. All active. One or two Evotomys are seen frequently. A small Peromyscus seen occasionally. Peromyscus darts across the cage, traveling about a foot at each movement (cage only two feet long). Evotomys, on the other hand, travels only a few inches at a time, pauses to sniff about more, directing its nose in various directions, occasionally rising up on hind legs; frequently climbs side of cage and tries wires

with teeth. (Peromyscus does not do this.) In general, Evotomys seems to have more of an exploring nature. Peromyscus darts more directly toward a given spot.

The Peromyscus specimens in our cages occasionally jumped over each other as they moved from place to place; Evotomys did not. Seton ('09) says that Evotomys proceeds at a steady trot, not bounding like a deer-mouse.

Toilet.—Evotomys was observed occasionally to wash its face and sides, and now and then a pair seemed to be cleaning each other. Peromyscus washed its face and sides more rapidly than did Evotomys, and then with forepaws and tongue went quickly over the length of the tail. Evotomys seemed to devote no attention to the cleaning of its tail.

Voice.—The caged Peromyscus was not heard to utter any sound. Evotomys uttered a low "chut-chut", similar to that of a red squirrel. Seton calls the red-back a "remarkably silent species".

Disposition.—On one occasion specimens of both these forms were taken in the same live trap. They seemed to have gotten along well together. L. P. Brown ('23), in Colorado, states that individuals of Evotomys fought each other whenever they met, but fled from Peromyscus. Hatt ('30) found that the members of some pairs in captivity fought each other, others did not.

Diurnal activity.—Storage.—Our caged Evotomys were frequently active during the day. Dice ('22) also found the form somewhat diurnal. Seton ('09) says of these mice that they are "largely if not chiefly diurnal", and remarks further that they do not hibernate, but lay up stores of roots, nuts and seeds for winter. Our own captive specimens were also frequently found to stow away food, to be eaten later.

Home range.—Regarding the home range of Evotomys, Seton ('09) speaks of a "very small home locality for each individual, less than 100 feet across". Our own observations tend to support this view. In the live-trap studies at Conquest, 10 females and 8 males were marked with an ear punch, and then released at the same place. The traps were at the same time closed for 24 hours. As indicated in Table 28, 60% of the females and 87.5% of the males were recaught. Three females and three males were recaught in the same traps where they had formerly been taken, and furthermore, two of these males were retaken a second time in the same places. This would seem to indicate that these little mammals stay in one locality for some time, and that their individual home range is small. As previously mentioned, they may possibly "explore" their home locality very thoroughly, as indicated by place perception values.

Data on breeding activities for Evotomys are presented in Table 31. Only two lactating individuals were taken. Pregnancy dates, mostly from Conquest, are distributed throughout the whole summer season. The number of embryos varies from 2 to 6, averaging 4. Seton ('09) declares that Evotomys is very prolific. He quotes Kennicott as having found eight young in a nest, and Merriam, four. Harper ('29) records instances of 6, 4, and 5 embryos.

The following item is taken from my field notes of several years ago, written at Jessup Lake, in the Adirondacks, and seems worth inserting here as an interesting example of maternal behavior in Evotomys:

> Wednesday, June 13, 1928, noon. As we ate dinner we watched a mother Gapper mouse. She had a nest underneath the water tank of the old stove. The location was getting too hot for comfort, so she had to move. To reach the nest she ran up the leg of the stove and in through a crack. Then we would hear a little rustling and perhaps a squeal, and presently a young mouse would drop to the floor at the corner of the tank. Then down would drop the mother mouse, pick up the young one in her teeth, and head for a crack in the wall of the shanty. Thus she moved her family of six, with slight variations in the procedure. Once she dropped two young at once, and carried them away one at a time. Each time on the return trip she seemed to search about on the floor below the stove before proceeding to the nest. At the crack in the cabin wall she would try to push a young one through ahead of her. Sometimes she succeeded thus, usually not. She would then drop the youngster and go through alone, turn around, re-enter, seize it by the neck, and thereupon back out through the hole, dragging the young mouse after her. Smith (my companion) found that the mouse was moving into an old mattress which lay just outside the shanty wall.

Social groups.—In 17 instances a male and a female were taken together in traps, on the same day; in 19 instances two males were thus taken; and in two instances, two females (Table 25). A few instances of larger groups,—3 and 4, and one of 6, are listed in the table. Seton ('09) says that these mice are often found in numbers together, but the results from our rather limited data hardly support that statement.

Measurements.—Field measurements of all Evotomys specimens caught at St. Mary's Pond and at Constantia, places only a few miles apart, gave a mean length for males of 133.5 mm., plus or minus .837; and for females, 136.4 mm., plus or minus 1.309 (Table 35).

Measurements of the larger numbers taken at Conquest were considered separately, and these showed a mean length of 125.42 mm., plus or minus .764, for males; and of 128.17 mm., plus or minus 1.646, for females. Both sets of figures show the females to be slightly larger. Specimens from Conquest averaged smaller than those from St. Mary's Pond and Constantia. This is doubtless due to the fact that at Conquest more immature individuals were included, because of greater breeding activity at that time. Standard deviation figures for specimens from St. Mary's Pond and Constantia, for example, are a little above 9; and those for specimens from Conquest are above 11 for the males and above 16 for the females.

For *Evotomys gapperi,* in Michigan, Dice ('27) gives a length of 130–158 mm. Harper ('29), for 3 adult males from the Adirondacks of New York, found an average length of 140–145 mm., and for 6 adult females, 139–156 mm. Hatt ('30)

measured ten adults for an average of 141 mm., and Seton gives an average length of 146 mm. for this species.

Our own measurements were lower than all these, doubtless because of the inclusion of some immature specimens. As before mentioned, these measurements indicate the size of the individuals actively ranging throughout the habitat, and not necessarily the size of adults, a fact of greater value, perhaps, from an ecological point of view.

TABLE 31. BREEDING HABITS OF *Evotomys Gapperi Gapperi*, INCLUDING RECORDS FOR THREE SEASONS.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
June 25, 1934	.....	.....	
	July 3, 1934	6	
	July 4, 1934	6	
	July 5, 1934	6	
			July 11, 1931
	July 13, 1932	3	
	July 14, 1934	2	
	July 16, 1932	6	
July 17, 1934	.....	.....	
	July 18, 1932	5	
	July 22 ,1934	3	
	July 22, 1934	5	
July 23, 1934	.....	.....	
	July 24, 1932	4	
	July 24, 1934	5	
	July 29, 1934	4	
July 31, 1934	.....	.....	
July 31, 1934	.....	.....	
	Aug. 6, 1934	4	
	Aug. 8, 1934	4	
Aug. 10, 1934	.....	.....	
	Aug. 11, 1934	5	
	Aug. 12, 1934	5	
Aug. 13, 1934	Aug. 13, 1934	5	
Aug. 13, 1934	.....	.....	
Aug. 14, 1934	Aug. 14, 1934	6	
Aug. 16, 1934	Aug. 16, 1934	4	
	Aug. 18, 1934	2	
Aug. 19, 1934	.....	.....	
Aug. 20, 1934	.....	.....	Aug. 20, 1934

In general it would appear from the present study that Evotomys frequents the same general types of habitat in which also Peromyscus occurs, although it is found a little more frequently in moist woods than in the dry woods so often frequented by Peromyscus. In their daily lives the two forms probably for the most part avoid each other. Peromyscus is active at night, and Evotomys is more or less active also by day. Their relations to other small mammals of their community are undetermined. Apparently they enter burrows without fear of Blarina, as indicated by their low place perception value, but whether occasional individuals are killed by Blarina was not ascertained.

ZAPUS HUDSONIUS HUDSONIUS

The meadow jumping mouse was taken in all of the five seasons covered by the present study. At Brewerton a considerable abundance of them was found along Little Bay Creek, where the tall weeds along the edge of a mud flat harbored a population estimated at 72 per acre (Table 17) and constituting 69% of the small-mammal community. Only two specimens were taken on an early test line of traps in the bog near the outlet of St. Mary's Pond, and no more were taken as we moved our lines northward around the pond. Later, a unit of traps operated for a few days in the tall grass below the outlet resulted in a catch of four specimens. However, there was very little of the grassy meadow habitat, apparently favored by the species in this territory, except farther down the outlet, in untrapped territory. Zapus was fairly common in the meadows at Constantia, where the estimated average population was 21 per acre (Table 16), comprising 37% of the small-mammal community (Table 19). It was less abundant at Marcellus, although the total catch was 62,—an average of 11 per acre, and comprising 8% of the small-mammal community. The species was fairly common at Conquest, the average per acre here being 25, which represented 38% of the small-mammal community. Thus, in general, the population per acre seems to be more nearly constant than does the community percentage of this species, indicating that the animal is rather unaffected by variations in abundance of the other associated small mammals.

Zapus is distinctly an animal of the meadows and fields, although occasionally it wanders into low moist woods. At Constantia, its moist woods-meadow ratio was 0 to 100 (Table 21); at Marcellus, 15 to 85; at Conquest, 11 to 89. It was never taken in the woods at Brewerton. Seton ('09) says that it is "commonly found in thickets by meadows, and along edges of woods". Goodwin ('32), writing from Connecticut, says that Zapus "seems to adapt itself to all kinds of conditions, dry open hilltops half a mile or more from water and again in large flooded cranberry bogs, etc."

Seton ('09) considers Zapus a burrowing animal, but our own observations furnished only negative evidence along this line. In places where we took Zapus in largest numbers, the weed and grass tangle was usually thick, and we found practically no burrows. For instance, at Brewerton, only 2 out of 43 specimens were taken in burrows. As indicated in Table 8, the open-cover-burrow ratio for the species at Constantia was 27–62–11; place perception value, 42. At Marcellus the ratio was 6–90–3, and at Conquest, 21–71–8, indicating in all cases a high "preference" for cover. In all localities its bait perception values were rather low (Table 8 and Plate 2). At Brewerton and Conquest the "preference" was for peanut, the bait perception values being 24 and 16, respectively; at Constantia and Marcellus raisin was the favored bait. We obtained no evidence as to its natural food. But Seton ('09) says that it "feeds on beech-nuts, various seeds and berries"; and Anthony ('28, p. 459) mentions "vegetation, seeds and grains."

Hibernation.—*Zapus h. hudsonius* is known to hibernate, and, according to Seton, its hoarding habit is well developed.

Progression.—Although Zapus is called a "jumping-mouse", it would seem that—in the sense of longer leaps—jumping as a mode of progression is a secondary one in the normal activities of the present species. In the habitats where we found the animal common, the grass was usually so thick as to discourage this method of locomotion. On one occasion at Brewerton, however, we watched a Zapus escape by a series of leaps about two feet in length. But Seton ('09) says that it "never jumps in its ordinary traveling or when searching for food. It leaps only when it must save its life"; and further, that it is "apparently a poor swimmer". Stone and Cram ('10) remark that jumping mice are "decidedly less intelligent than most mice", and "apparently never look before they leap". They mention having seen it swim strongly in a current.

Sociability.—As regards social tendencies, Seton ('09) remarks that "evidence goes to show that this species pairs". As indicated in Table 25, in ten instances a male and a female were taken in the same trap unit in a one-day period; in three instances two females were taken, and in five, two males. Further, one group of two males and a female was taken, two groups of two females and a male, and one group of three males. On one occasion at Brewerton (July 30, 1930) a female and four males were taken close together during the same night. Several authors mention the fact that Zapus is occasionally active during the day. On one or two occasions only, in the present study, did we start a jumping mouse during the day's work. Seton ('09), however, remarks in this regard that "we can indeed find evidence for each of the twenty-four hours". At Brewerton, where we visited the trap lines twice a day, the results showed 34 morning catches, 3 evening catches, and 5 that were doubtful as to the period. On the whole these results would seem to indicate a nocturnal or crepuscular habit of the jumping mouse.

Nest and young.—No nests of Zapus were found in the course of the present study. The form is said by Seton to nest in hollow trees, tufts of grass and shallow burrows; and its winter nest is said to be two or three feet below the surface.

According to Preble ('99), the species has five to eight young per litter, and one or two litters per year.

Breeding records obtained in the present study are presented in Table 32, which show pregnancies throughout the summer months, with an average of 4.4 embryos per litter. These records, though relatively few, would appear to show that the species may have more than one litter in a season.

Wandering tendency.—Seton ('09), in the absence of any definite evidence as to the size of the home range, is inclined to think that it travels "farther than any other of the Mice." This is interesting in connection with our own studies on the wandering tendency. Our results on this question, shown in Tables 10 and 11, indicate a highly variable wandering tendency for this species. Sometimes one sex, sometimes the other, gives the higher value in this respect, but frequently a rather high wandering tendency is suggested, correlated perhaps with a tendency to concentrate its population as the habitats become dry in the course of the summer.

Sex ratios.—These, as listed in Table 13, show much variation, ranging from 41% to 74% males in the same type of meadow in different seasons. Apparently the sex ratio in this species is not correlated with the habitat, as it appeared to be in the case of some of the other small mammals here concerned.

Field measurements (Table 35) showed a mean length for males of 202.6 mm., plus or minus .657; and for females, 207.9 mm., plus or minus .811. Anthony ('28, p. 459) says that the sexes are equal in size and gives the length as 8.7 inches (220 mm.). Schmidt ('31), in Wisconsin, found 13 specimens averaging 207 mm., with a range of 185 to 220 mm. Dice ('27) finds the size ranging from 185 to 248 mm. This agrees fairly well with the range of our own measurements as

Table 32. Breeding Habits of *Zapus Hudsonius Hudsonius*, Including Records for Four Seasons.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
	June 17, 1930	4	
	June 17, 1933	4	
			June 25, 1932
	June 27, 1933	4	
	June 27, 1933	4	
	July 8, 1934	6	
July 12, 1934	.....	.....	
July 12, 1934	.....	.....	
July 19, 1934	July 21, 1934	4	
	July 22, 1932	3	
	July 23, 1930	6	
	July 26, 1933	5	
	July 28, 1933	3	
	July 29, 1933	5	
			July 31, 1932
	Aug. 5, 1930	?	
	Aug. 8, 1930	5	Aug. 7, 1932
	Aug. 9, 1930	7	
	Aug. 10, 1930	4	
	Aug. 10, 1932	3	
	Aug. 11, 1932	?	
	Aug. 13, 1932	5	Aug. 13, 1932
	Aug. 19, 1932	4	

indicated in Plate 8, except that we evidently included two immatures, and none of our specimens was over 230 mm. long. The standard deviation in our measurements was above 10 for each sex, indicating considerable variability.

In its meadow home, Zapus, in the areas studied, was found in association with Blarina and Microtus, and sometimes with Sorex.

NAPAEOZAPUS INSIGNIS INSIGNIS

The woodland jumping mouse was found in four localities. At Brewerton and at Conquest it was scarce, but at St. Mary's Pond and at Constantia it was sufficiently common to yield some significant data in line with our particular studies. Our total catch for the four seasons was 127 individuals. The species seems to have been considered rare in many sections of the country (Chapin, '22;

Soper, '23; Surber, '23; and others). Anthony ('28, p. 464) says that the jumping mice are "erratic in distribution, more often rare than common and yet in some localities being encountered as fairly abundant".

While the form here concerned is called the woodland jumping mouse and, in general, is most numerous in the woods, our records seem to indicate that it is not so strictly confined to the woods as the meadow jumping mouse is to the meadow. At Constantia the moist woods-meadow ratio of Napaeozapus was estimated as 74–26 (Table 21), indicating its presence in some habitats classified as meadow, although in most instances these places were not far from the edge of the woods. Within the woodland habitat it was found to frequent mostly the low, moist woods. Thus, at St. Mary's Pond the dry woods—moist woods ratio was 20–80, with a "perception" value of 60 (Table 23); and at Constantia the ratio was 39–61, with a "perception" value of 22. When the animal thus shows a tendency toward the low moist woods habitat, it is not surprising to find that it occasionally wanders out into the moist meadow near by. This is also in general agreement with the findings of Snyder ('24), who says that "undergrowth seems to be essential although its home may be only adjacent to such cover. It appears to prefer the vicinity of clearings and the banks of streams, not the dark interior of heavily forested areas". This statement and our own observations would indicate that Napaeozapus is a good example of a "forest-edge" animal, as discussed by Shelford ('13, p. 262); and by Townsend and Smith ('33) with reference to the white-tailed deer. There are among our local mammals probably few better examples of forest-edge animals than these. Goodwin ('32, p. 37) says water seems to be a necessary part of the habitat for Napaeozapus.

Population per acre.—At St. Mary's Pond and at Constantia, the estimated population of Napaeozapus per acre (Table 16) varied from 2 to 24. From Tables 16 and 19 we note that in the dry woods there were an estimated 6 to 11 individuals per acre, representing from 8% to 11% of the small-mammal community. For moist woods the estimates were 24 per acre at St. Mary's Pond, and 17 per acre at Constantia, representing respectively 21% and 16% of the small-mammal community. In the meadows at Constantia we found an estimated average of 6 Napaeozapus per acre, about 10% of the small-mammal community.

Place "perception".—With regard to place "perception" (Table 8 and Plate 3), the results of the two seasons were in rather close agreement. "Perception" values were 38 and 35, with a decided "preference" shown in each case for the open places in the habitat. Apparently the animal is not a burrowing form, although it is known to nest underground. Perhaps this preference for open places is correlated with its jumping habits. Unlike Zapus, the woodland jumping mouse, when undisturbed, apparently, often progresses by short leaps. This was indicated by tracks in small mud-flats along the streams at St. Mary's Pond. Here, in a locality where Napaeozapus was the only jumping mouse taken, we frequently observed groups of tracks a few inches apart, which doubtless had been made by the woodland jumping mouse. This bears out Fraleigh's ('29) observations on some individuals of this species, which were seen to progress by little leaps five or six inches in length. Snyder ('24) watched a female

Napaeozapus that was carrying material to its nest. The animal carried the material in its mouth, helped by the front feet, progressing by "short and slightly labored" jumps of two feet. The same author describes leaps of seven feet by the unburdened animal when leaving its nest, and states that a frightened Napaeozapus escaped by jumps of ten to twelve feet. No doubt the long tail of the species is invaluable as a balancing organ at such times. In this connection Buck, Tolman and Tolman ('25) describe an interesting series of experiments with house mice to show the value of the tail for balancing purposes.

Runways.—No evidence of runways used by Napaeozapus was here noted,—unless the abundance of tracks in some open mud flats along the streams might be termed such, but these tracks did not suggest anything like a runway in the usual sense. A trail may, perhaps, be less likely to develop where an animal progresses by short leaps. Yet, Saunders ('21) describes a "faint runway on dead leaves", in which a specimen of Napaeozapus was taken.

Food.—Very little information as to the food of Napaeozapus was obtained in the present study. However, an individual that was kept in a cage for a few days was offered a variety of foods, but it ate only a few chokecherries and nibbled a little on Jewel weed. Bait perception studies on the trap lines (Plate 2 and Table 8) indicated a preference for raisin over peanut and bacon.

Disposition.—The following passage from my notes on the caged specimen shows something of its disposition: Aug. 5, 1931. Napaeozapus is still very wild, more so than any other species we have in our cages. It leaps about the cage and then squats down to rest, in one spot, quivering constantly. However, it occasionally washes its face during such resting spells, but it is a question whether this is any sign that the animal is at ease. It points its ears forward in response to a sound in that direction. We have not noted this in our other little caged mammals.

Groups.—From Table 25 we note two instances where a male and a female Napaeozapus were taken on the same trap line on the same day; six instances of two males; two of two females; and three of two males and one female. It seems likely that some of these represent family groups. Perhaps the more frequent instances of males being thus taken is of significance, but more information on this question is needed.

Home range.—Information on the extent of the home range of Napaeozapus seems to be lacking in the literature. It would appear likely that an animal with such leg power might range over a considerable area, especially since its place "perception" value indicates that it frequents the open places within its habitat. Studies on wandering tendency, however (Tables 10 and 11), show varying results.

Nests.—At St. Mary's Pond considerable time was spent in searching for nests of this species, but without avail. Snyder ('24), however, has described such a nest. After watching the female carrying material into the nest burrow, one evening, he was unable the next morning to see the opening, even though he

was very sure of its location. It had been neatly plugged from below. The nest, which was in a tunnel a few inches below the surface, contained five young, naked and blind, but already showing the characteristic white tail-tip of the species.

Pregnancy and lactation.—In Table 33 are presented records on pregnancy and lactation in *Napaeozapus i. insignis,* as obtained in the course of the present study.

Table 33. Breeding Habits of *Napaeozapus I. Insignis*, Pregnancy and Lactation Records for Two Seasons.

PREGNANCY DATES	Embryos	Lactation dates	Immatures
		June 23, 1932.....	
		June 23, 1932 (just finished)..	
		June 23, 1932 (just finished)..	
July 8, 1932.....	?	.....	
July 14, 1932.....	6	.....	
July 17, 1932.....	4	.....	
July 22, 1932.....	4	.....	
July 23, 1932.....	5	July 23, 1931 (finished).....	
			July 23, 1932 (female)
			Aug. 7, 1932 (male)
Aug. 9, 1932.....	5	.....	
Aug. 15, 1932.....	5	.....	

From these records it would seem that this species has an average of five young to the litter—which agrees with the statement of Anthony ('28, p. 464). The presence of lactating females in June and of embryos in July suggests that there may be two broods of young in the season, although Anthony (*loc. cit.*) says that in the jumping mouse group "but one litter is raised in a season". It is interesting to note that Harper ('29), for the Adirondacks, states that "among a considerable number of adult females taken between July 24th and August 4th, I found none with embryos." These dates show a close correlation with those in the above table.

Sex ratio.—For the two seasons (Table 13) males constituted respectively 50% and 62% of the catch in dry woods, and 43% and 67% in moist woods.

Measurements.—Field measurements of Napaeozapus are presented in Plate 8 and Table 35. Only two of our specimens were adjudged to be immatures, but it is possible that sub-adults also were included.

Total length.—The mean lengths were 223.0 mm., plus or minus .866 mm., for males; and 225.8 mm., plus or minus 1.518 mm., for females. This agrees fairly well with Soper's ('23) measurements for two specimens taken in Ontario, of 227 mm. and 230 mm. Mearns ('98, p. 348) remarks that "females are slightly larger and heavier than males." Goodwin ('24 and '29), for two lots of specimens of ten each, from Quebec, found average lengths of 236 mm. and 238.4 mm., respectively. Harper ('29), for six adult males from the Adirondacks, found an average length of 227.7 mm.; and for six females, 237.8 mm. Anthony

('28, p. 463) gives an average of 9.5 inches (240 mm.) as typical for the species. These greater measurements for northern specimens suggest the possibility that the species attains a larger size in that part of its range.

Tail and foot length.—Field measurements of the tail gave a mean length of 141.1 mm., plus or minus .664 mm., for males; and 141.7 mm., plus or minus .726 mm., for females. The feet measured 30.62 mm., plus or minus .096 mm., for males; and 30.34 mm., plus or minus .094 mm., for females.

Standard deviation.—For the total length this was 9.78, plus or minus .612, for males; and 16.51, plus or minus 1.173, for females. This greater variation among the females than among the males was the reverse of the condition found for the meadow jumping mouse.

Community relations.—Napaeozapus lives where it comes in contact to some extent, perhaps, with all the other little mammals of its community. In the woods its preference for the open places would seem to place it in direct contact with Peromyscus, the habits of which are similar in this respect. It is possible, however, that the two are active at different hours, although opinion seems to be that both are nocturnal animals. Harper ('29) saw an individual *N. i. insignis* twice, at dusk, and suggests crepuscular habits for the species. Sorex and Blarina probably do not as a rule come in contact with this jumping mouse, because of their subterranean habits. Evotomys, however, may meet with Napaeozapus, so far as its place tendencies are concerned, but perhaps it is more diurnal in its habits.

When Napaeozapus occasionally leaves the woods for an adjacent meadow it may come in contact with Microtus and Zapus. Around St. Mary's Pond, however, the two latter species were scarce, for good meadow conditions were almost lacking; but it is our opinion that Zapus would certainly have been present in the weeds at the outlets of the brooks if the territory had not been previously occupied by Napaeozapus. Being a larger animal, it would not be surprising if Napaeozapus would tend to drive Zapus out. It seems that such may have been the case at St. Mary's Pond, but evidence was lacking.

MICROTUS PENNSYLVANICUS PENNSYLVANICUS (ORD)

Population.—The meadow mouse was met with in all localities investigated in the course of the present study. At Brewerton most of our work was carried on in woods, but several quadrats and lines were operated in meadows or along the edges, and here Microtus was taken. In general, good Microtus territory in this section was not easy to find, and in those localities where it was found it was not extensive. As indicated in Table 17, the population was estimated at not more than 26 per acre, at the most.

At St. Mary's Pond we found Microtus only rarely, chiefly because there was a lack of suitable meadow. Test lines in the cranberry bog caught a few, and a small patch of isolated meadow, only a few yards across and entirely surrounded by woods, in the upper reaches of East Brook valley, yielded two specimens, representing a population estimate of 12 per acre. At Constantia, a few meadow mice were caught here and there at the meadow edges, but not enough to warrant any serious attempt at studying the species here. It is well known that the

numbers of these animals are quite variable in different seasons, and it may be that the summers of 1930, 1931 and 1932 were merely poor Microtus seasons, and that the reason for their scarcity was not one of locality or habitat alone. Middleton ('30) and others have indicated that voles show cycles of abundance reaching maxima every four years.

At Marcellus, in 1933, we found Microtus quite abundant in the meadow weeds and the mixed woods-meadow habitats which were characteristic of this general locality. Population estimates here ran as high as 67 per acre in the meadow (see Table 16). In 1934, at Conquest, the species was also fairly abundant, the estimates being 30 and 24 per acre, respectively, in meadow and marsh.

At Constantia, Microtus was found in meadows and in grassy spots surrounded by woods, but not in the woods proper.

Place "perception".—In place "perception" Microtus showed values of 45 at St. Mary's Pond, 35 at Constantia, 63 at Marcellus and 43 at Conquest (see Table 8). It showed a strong preference for "cover" and its habitat is usually, of course, a cover of weeds and grass. However, this fact does not weaken the value of the open-cover-burrow classification. There is a certain ecological similarity between an animal which chooses cover, in a territory where a free choice among open, cover, and burrow places is presented, and another animal which is found only where the habitat consists almost entirely of "cover". Both are "cover-preferring" animals.

As indicated in Table 8, the open-cover-burrow ratios for Microtus were 27–64–9, 14–57–29, 0–76–24, and 8–62–30, respectively, in four successive seasons. In the locations where it was found there was little evidence of underground burrows. There were, however, the usual runways or tunnels in the grass, and these were considered in connection with this study as the equivalent of burrows. They represent passageways in which the animal can move along freely and yet be in contact with something below, above and at the sides. Hatt ('30, p. 527) has described the mode of origin of one of these runways: ". . . . these pathways . . . are constructed by the mice themselves. At first the grass is merely parted and pushed aside, or trampled down somewhat but eventually the stems are cut away so that the naked earth is exposed".

Food.—The food of Microtus has been mentioned by various naturalists. In general the animal is a vegetarian, but it will take meat when available. The studies on bait "perception" (Table 8, Plate 2), based on a limited number of catches in all but the last two seasons, indicated no very definite preference for bacon, peanut or raisin baits. The "perception" values were low: 15, 18, 24, 20 and 36, with only a slight leaning sometimes toward raisin and less often toward bacon. The catches for the two most productive seasons, however, indicated a preference for raisin.

Social tendency.—Microtus is frequently spoken of as a more or less colonial type of mammal, but the records on social groups (Table 25) do not support this view. In eighteen instances a male and a female were taken on the same day and in the same group of traps. In eleven instances two males were taken near together, and in two instances two females, indicating apparently a greater

tendency for males to run in pairs than for females. Two males and a female were taken together twice; and a male and two females, once. As indicated in the table, a group of two males and two females was taken once, and a group of five males, once. Such larger groups were encountered among the other small mammals only in the cases of Sorex, Peromyscus and Evotomys.

Home range.—But little information seems to be available as to the home range of Microtus. As indicated on tables 10, 11, and 13, the wandering tendency of the species seemed to be correlated with the sex ratio, a higher catch of males being correlated with a higher wandering tendency in this sex. The wandering tendency of Microtus also seemed to be higher in the cedar-meadow than in the weed-meadow habitat.

Community percentage.—Community percentages (Table 19) for Microtus vary greatly even in the same habitat. In meadow, for example, values range from 10% to 51%, corresponding with a similar range of population per acre (Table 16). Such wide range is to be expected if the abundance of an animal varies in cycles of a few years, and without any very direct relation to other small mammals of the community.

Habitat "selection".—Habitat "selection" ratios (Table 21) show that Microtus prefers the meadow to all other habitats contiguous. And in Table 24 we note that habitat "perception" appears highly variable in the two sexes.

Breeding habits.—A considerable number of pregnancies were found in Microtus in the Marcellus district, and these seem to strengthen the impression that the year in question was one in which the species was approaching a peak of abundance. The records in this connection, for three seasons, are given in Table 34. The evidence obtained agrees with published accounts that the meadow mouse breeds throughout most of the year. Some of the pregnant individuals showed signs of having recently lactated. The average number of embryos found was 5, the range being from 2 to 9. Bailey ('00) says that the gestation period for Microtus is 21 days: the number of young in the first litter, four, and six to eight in later litters.

Sex ratios.—Sex ratios for Microtus showed a high percentage of males for all four seasons (Table 13). For the first three seasons our records were hardly sufficient to be of significance by themselves, but in 1933 we found the same high percentage of males, 55% to 70%, in various habitats.

Measurements.—Field measurements for Microtus are found in Table 35. The mean length for males was 148.6 mm., plus or minus 1.239 mm.; for females, 151.1 mm., plus or minus 1.219 mm. The standard deviation was high,—above 18 for males; above 14 for females. This, of course, indicates that immatures were included in the catch, and is in line with the fact that the species breeds throughout the summer.

Interrelations.—In its grass and weeds habitat the meadow mouse is associated mostly with Zapus and Blarina, to some extent with Sorex, and occasionally with a few Napaeozapus and Peromyscus. Evotomys and Microtus

were never found together during these studies. At Brewerton, Microtus constituted 18% of the small mammals of the meadow, and at Constantia, 10% (see Table 19). In these localities Zapus was found to represent 36% and 39% of the small-mammal community. At Marcellus a reverse situation was found, Microtus constituting 51% of the community, and Zapus 8%. As mentioned above, these two forms are characteristic of the same grass and weed habitat, and it may well be that they are in some way competitors. However, in 1934, at Conquest, both Zapus and Microtus were fairly abundant.

A high percentage of Blarina, also, is shown for the seasons of 1930 and 1932, when Microtus was scarce.

The successional relationships of these three forms here mentioned is hard to determine without further data, but results such as they are suggest that Sorex and Microtus are to some degree mutually exclusive. In the woods-grass habitats, at Marcellus, Sorex especially was numerous, but Microtus not so abundant as in the near-by meadow. The meadow to cedar-meadow ratio for Sorex as calculated was 25 to 75; for Microtus, 66 to 34 (Table 21). Probably any form which increases very much in a given season, as Microtus seems to do when reaching the peak of a cycle, would at that time have some influence upon the abundance of other small mammals in a given habitat; but in normal years it may exert no influence.

"Pioneers".—An interesting point about Microtus is the presence of solitary individuals as well as of small groups of two and three, in remote and isolated patches of their habitat. For example, in the latter part of August, 1930, a large male was caught deep in the woods of Cicero swamp, south of Oneida Lake. Careful search for a period of six days afterward failed to yield any further specimens in this immediate area. The one lone individual was caught about half a mile or more from the outer edge of the woods. Another similar instance was the taking of two specimens of Microtus, a male and a female, in a small patch of grass along East Brook, at St. Mary's Pond. The meadow plot was only a few yards across and was about a quarter of a mile from the outer edge of the woods. Again, in 1932, two males were taken in a grassy place at least three-fourths of a mile from the outer edge of the woods, along a brook in the South Pond area. This also was in the latter part of August, and the specimens were taken on an area which had been covered in our trapping earlier in the summer. The same tendency of Microtus to wander was noted by Harper ('29), who found seven individuals in a grassy space "in the midst of a very extensive forest . . . an illustration of its ability to spread widely and to occupy small and well-isolated areas of favorable environment."

The examples cited suggest that occasionally Microtus may travel relatively long distances in search of new locations. The periodic migrations of such forms as the lemmings are well known. In connection with such phenomena, the presence of isolated groups of a species suggests that possibly in normal years the same migratory tendency may be present, but since the numbers then are small the wandering individuals are not noticed. This "pioneering" tendency would of course have a decided value to the species, especially to one of fluctuating numbers, reaching a maximum every few years, followed by almost complete disappearance.

TABLE 34. BREEDING HABITS OF *Microtus Pennsylvanicus Pennsylvanicus*, RECORD FOR THREE SEASONS.

MALES WITH ENLARGED TESTES	Pregnancy dates	Number of embryos	Lactation dates
	June 7, 1933	6	
	June 9, 1933	6	
	June 12, 1933	5	
	June 12, 1933	4	
	June 13, 1933	6	
	June 14, 1933	4	
	June 16, 1933	5	
	June 18, 1933	5	
	June 18, 1933	6	
	June 19, 1933	8	
	June 20, 1933	5	
	June 23, 1934	6	
	June 26, 1933	5	
	June 26, 1933	7	
	June 27, 1933	6	
			June 29, 1933
	June 30, 1933	4	
	June 30, 1933	9	
July 2, 1934	.....	.....	
	July 5, 1930	5	
July 8, 1933	July 8, 1933	4	
July 8, 1933	.....	.....	
July 8, 1933	.....	.....	
July 9, 1933	.....	.....	
	July 10, 1934	7	
July 11, 1934	.....	.....	
July 12, 1934	.....	.....	July 12, 1933
	July 13, 1933	?	
	July 13, 1933	6	
	July 14, 1933	4	
	July 15, 1934	6	
	July 17, 1934	6	
	July 19, 1934	3	July 19, 1933
	July 20, 1934	4	
July 22, 1934	July 22, 1934	4	
	July 25, 1933	2	
July 26, 1933	.....	.....	
July 28, 1933	.....	.....	
	July 29, 1934	6	
	July 30, 1933	3	
July 31, 1933	July 31, 1933	9	
	Aug. 2, 1934	4	
	Aug. 3, 1933	4	
	Aug. 3, 1933	5	
Aug. 6, 1933	Aug. 6, 1934	5	
Aug. 8, 1933	.....	.....	
	Aug. 9, 1933	4	Aug. 9, 1933
	Aug. 9, 1933	3	
	Aug. 11, 1933	5	
	Aug. 11, 1933	5	Aug. 12, 1933
	Aug. 18, 1933	4	
	Aug. 18, 1933	3	

Whatever the cause of the sudden disappearance may be, the few pioneers that had been able to cross certain barriers, in the course of normal migration, would probably live to multiply in a new locality. Later, perhaps, another small pioneer group might re-invade the area which had been depleted of its stock during the "crash" which followed the peak. Such a "pioneering" tendency might have an important bearing on the successional changes in the small-mammal population of the meadows—for example.

FIELD MEASUREMENTS OF SMALL MAMMALS

A practice was made of measuring, on the spot, every trapped specimen as soon as found. The measurements were taken with a small celluloid ruler, and with few exceptions were taken by the same person each season. Considerable care was exercised to insure uniformity in the procedure, and accuracy. Measurements of total length as thus recorded for seven species are summarized in Table 35 and in graphs that follow.

Obviously such data must be used with care. The animals had been dead for varying lengths of time when measured, and no distinction was made between immatures, sub-adults and adults. The results should not be compared with careful laboratory measurements of freshly killed specimens of known age. They have, however, a certain value with regard to the ecology of the animals studied. In a previous section of this paper there was discussed the wandering tendency of the species in question. The catches on the trap lines included animals large enough to range about in search of food. The measurements might be said to represent the "ranging activity size" of these little mammals. We cannot, of course, from such data determine the age of an animal at the time it leaves the nest and starts to wander about, but we can learn something about its size at that time. Thus the minimal sizes recorded in the trap-line data are of some importance.

The mean length of animals caught is probably not of great importance, although when compared with corresponding measurements of the same species from some other and more distant section they might have significance. It is of interest, however, to note that the mean length of females was slightly greater than that of males in *Sorex cinereus,* Evotomys, Zapus, Napaeozapus and Microtus, while in Blarina and Peromyscus the males exceed the females slightly in mean length.

Perhaps the most interesting figure is the standard deviation for each species (Table 35). It will be noted that males and females agree fairly well in their standard deviation in Blarina, Sorex and Zapus. Napaeozapus shows the greatest sexual difference in this respect, Sorex and Blarina show very low standard deviation figures, while the values for Peromyscus and Microtus are high. In Microtus this is because immatures are frequently taken in the traps. They start to range about at an early age, while in the shrews, where the variability is very low, all individuals taken in the traps during the summer months are of adult or nearly adult size. In other words, the young of Sorex and of Blarina do not leave the nest till late. The other members in the series show varying results.

TABLE 35. SUMMARIZED MEASUREMENTS ON TOTAL LENGTH ON SEVEN SPECIES OF SMALL MAMMALS.

		Number measured	Mean length (mm.)	Standard deviation
Blarina brevicauda				
(1930, 1931, 1932)	Males.....	198	119.5 ± .283	5.92 ± .200
	Females.....	224	117.4 ± .225	5.05 ± .161
Sorex c. cinereus				
(1933)	Males.....	113	97.8 ± .228	3.60 ± .175
	Females	73	99.4 ± .389	4.93 ± .275
Peromyscus l. noveboracensis				
(1933, 1934)	Males.....	91	159.7 ± 1.014	14.33 ± .716
	Females.....	44	158.4 ± 1.923	18.91 ± 1.359
Evotomys g. gapperi				
(1931, 1932)	Males.....	53	133.5 ± .837	9.04 ± .592
	Females.....	16	136.4 ± 1.309	9.25 ± 1.114
(1934)	Males.....	95	125.4 ± .764	11.1 ± .558
	Females.....	46	128.1 ± 1.646	16.6 ± 1.166
Zapus hudsonius				
(1930, 1932, 1933, 1934)	Males.....	117	202.6 ± .657	10.54 ± .461
	Females.....	80	207.9 ± .811	10.76 ± .579
Napaeozapus i. insignis				
(1931, 1932)	Males.....	58	223.0 ± .866	9.78 ± .612
	Females	50	225.8 ± 1.518	16.51 ± 1.173
Microtus p. pennsylvanicus				
(1933)	Males.....	106	148.6 ± 1.239	18.91 ± .873
	Females	65	151.1 ± 1.219	14.61 ± .863

SUMMARY AND CONCLUSIONS

The present study may be termed a quantitative field study of a total of seven species of small mammals in various localities in the general region of Syracuse, N. Y. The study extended over five seasons. Habitats were classified and the small-mammal population of each was studied from various points of view. A method of handling large numbers of U-lever mouse traps is presented, including the use of a "stationary line" and a "moving quadrat". The data collected were organized and analysed under various headings. The principal results are as follows:

1. "Bait perception". The various species differed in their responses to the three baits used, namely, bacon, peanut and raisin. A "bait-ratio" was devised for each species in a given season, and the degree of apparent "choice" is expressed as a "bait perception" value (Table 8 and Plate 2).

Sorex and Evotomys were taken most generally on peanut bait, Blarina on bacon, and Zapus on peanut and raisin; Napaeozapus was caught most frequently on raisin bait. The highest "bait perception" values were shown by Sorex.

2. "Place perception". Small mammals seem to be sensitive to certain minor features of their surroundings, described under the three terms "open places", "cover places", and "burrows". Such responses are expressed in the form of a "place ratio" and a "place perception" value for each form and season (Table 8 and Plate 3). Blarina and Sorex were taken mostly in burrows or in "cover"; Peromyscus and Napaeozapus most frequently in the open; Zapus and Microtus

in "cover"; Evotomys showed a remarkably low place "perception", indicating no definite "preference" for any of the "places" listed.

3. "Wandering tendency". A method of measuring numerically the tendency of the various forms to move into a new territory is presented. This "wandering tendency value" differs for different species, habitats and seasons (Table 11). In some cases the two sexes show variable results with regard to this tendency (Table 10).

4. Sex ratios vary in some cases with the habitat (Table 13). Blarina shows a higher percentage of males in dry woods than in low woods. Peromyscus, Evotomys and Microtus show over 50% males in all catches. Zapus and Napaeozapus show variable sex ratios in similar habitats in different seasons.

5. The high percentage of males in the catches of Peromyscus, Evotomys and Microtus is apparently correlated with the higher wandering tendency of the males (Table 10).

6. A method of studying the small-mammal population per acre is presented (Tables 15 and 16). Results for four seasons indicate that populations of Blarina and Microtus are highly variable and perhaps are associated with a cycle of abundance. Populations of Peromyscus, Zapus and Napaeozapus are less variable. Total small-mammal populations in moist woods in successive seasons are rather uniform, varying between an estimated 102 and 114 individuals per acre. Total populations in dry woods and in meadow are more variable in different seasons.

7. For the small-mammal communities, the "community percent" was computed for each species in the habitat (Tables 19 and 20). In a given habitat, abundance of one species of these small mammals, seems, in general, to have but little effect on abundance of the other species present, as indicated by a study of both the population per acre and community percent.

8. Habitat "selection" or "preference" ratios represent a method of studying a species with regard to its "preference" for one of two adjoining types of habitat (Tables 21 and 22). Thus, Blarina was found to favor moist woods rather than dry woods or meadow; Sorex, to favor moist woods rather than dry woods or meadow, and likewise marsh, cedar-meadow or sweet flag rather than meadow. Peromyscus shows a slight preference for dry woods as opposed to moist woods, but avoids meadow. Evotomys and Napaeozapus seem to favor moist woods rather than other types of habitat. Microtus favors meadow over the other habitats where it occurs. In Blarina, Peromyscus, Zapus and Microtus, males do not always show the same apparent habitat preference as do the females (Table 22). In Sorex and Napaeozapus the "selection" is similar for the two sexes.

9. Habitat "perception" is a term used in an attempt at a numerical expression of the apparent degree of response to adjoining habitats shown by a species (Tables 23 and 24). Blarina appears to show low "perception" or "discrimination" between dry woods and moist woods. Its reaction toward other types of habitat varies considerably. Peromyscus and Napaeozapus gave highly variable "perception" values for dry woods and moist woods habitats. Peromyscus, Evotomys, Zapus and Microtus gave high "perception" values, as between moist woods and meadow. But the different sexes of the same species did not always give similar habitat "perception" values (Table 24).

10. In none of the several species included in the study were individuals taken in groups of larger size. In Blarina, groups of two individuals that may occur, appear to bear no relation to the sexes. In Sorex, Peromyscus, Evotomys and Microtus, two females are apparently less likely to be taken near each other than are two males, or a male and female.

11. A few experiments in marking, releasing and retrapping Evotomys and Peromyscus indicated for Evotomys that both sexes are likely to be taken again in the same place, while in Peromyscus the females are more likely to be retaken than are the males.

12. Field measurements for seven species of small mammals are presented, tabulated to show mean length and standard deviation from mean length. The latter item has ecological significance in that it provides a means of comparing and contrasting species as to their "ranging-activity size". The species here concerned which breed during the mid-summer months, and the young of which leave the nest as immatures, show a higher standard deviation. Blarina and Sorex show the lowest standard deviation, possibly because they do not rear young during the mid-summer months.

LIST OF PLANT SPECIES BY HABITATS*

The section of Central New York in which the preceding studies were made lies within what Bray ('15) has designated as the Alleghany-Transition forest zone. The indicator tree species for this zone are white pine, hemlock, hop hornbeam, blue beech, yellow birch, beech, black cherry, sugar maple, soft maple, mountain maple, basswood and white ash. In general in the woodland areas in which the trapping was carried on the dominant trees were among those here listed. However, the ground cover varied considerably among some of the localities, since they occupied a position between the Alleghany-Transition and the Canadian-Transition zones. The St. Mary's Pond and Constantia localities are good examples in point. At these two places, with the exception of a few aspens, the indicator tree species were from the Alleghany-Transition zone, while the ground cover was composed chiefly of plants like bunchberry, goldthread and Canada yew, which are listed by Bray as typical of the Canadian-Transition zone. The ground cover is discussed further in connection with vegetation lists of the various habitats concerned.

The following is a grouping of the localities in which the trapping was done, under the five habitat headings outlined in the Introduction: dry woods, moist woods, meadow, woods-meadow and lesser habitats. For each locality are listed the plants found there. The last mentioned localities are classified according to the nature of the plant growth, under three heads: A, trees; B, shrubs, vines and tall herbaceous plants; C, low herbaceous plants (the ground cover).

* Prepared by John Pearce and Charles P. Brown, field assistants.

I. Dry Woods

St. Mary's Pond

A. Hard Maple	*Acer saccharum* Marsh.
Hemlock	*Tsuga canadensis* (L.) Carr.
Beech	*Fagus grandifolia* Ehrh.
Trembling Aspen	*Populus tremuloides* Michx.
Large-toothed Aspen	*Populus grandidentata* Michx.
Yellow Birch	*Betula lutea* Michx f.
White Pine	*Pinus Strobus* L.
White Cedar	*Thuja occidentalis* L.
Red Oak	*Quercus borealis maxima* (Marsh.) Ashe
B. Maple-leaved Vibernum	*Vibernum acerifolium* L.
Moosewood	*Acer pennsylvanicum* L.

Some reproduction of trees listed above.

C. Partridge Berry	*Mitchella repens* L.
Yellow Clintonia	*Clintonia borealis* (Ait.) Raf.
Wintergreen	*Gaultheria procumbens* L.
Wild Ginger	*Asarum canadense* L.
Christmas Fern	*Polystichum acrostichoides* (Michx.) Schott.

Constantia

A. Hard Maple	*Acer saccharum* Marsh.
Beech	*Fagus grandifolia* Ehrh.
Hemlock	*Tsuga canadensis* (L.) Carr.
Yellow Birch	*Betula lutea* Michx. f.
Red Oak	*Quercus borealis maxima* (Marsh.) Ashe
White Pine	*Pinus Strobus* L.
Large-toothed Aspen	*Populus grandidentata* Michx.
B. Maple-leaved Vibernum	*Vibernum acerifolium* L.
Shad Bush	*Amelanchier canadensis* (L.) Medic.
Moosewood	*Acer pennsylvanicum* L.
Witch Hazel	*Hamamelis virginiana* L.
C. Goldthread	*Coptis trifolia* L. Salisb.
Partridge Berry	*Mitchella repens* L.
Wintergreen	*Gaultheria procumbens* L.
Bunchberry	*Cornus canadensis* L.
Yellow Clintonia	*Clintonia borealis* (Ait.) Raf.
Shield Fern	*Aspidium* sp.

Mud Pond, Marcellus

A. Hard Maple	*Acer saccharum* Marsh.
Basswood	*Tilia glabra* Vent.
Beech	*Fagus grandifolia* Ehrh.
Hemlock	*Tsuga canadensis* (L.) Carr.
Hop Hornbean	*Ostrya virginiana* (Mill.) Koch.
Blue Beech	*Carpinus caroliniana* Walt.
Black Cherry	*Prunus serotina* Ehrh.

B. Reproduction of trees above.

C. Ground cover here was very sparse. The following species were scattered about:

Wood Nettles	*Laportea canadensis* (L.) Gaud.
Trilliums	*Trillium* spp.
Snakeroot	*Eupatorium urticaefolium* Reichard

Conquest, 1934

A. Sugar Maple	*Acer saccharum* Marsh.
Beech	*Fagus grandifolia* Ehrh.
Hemlock	*Tsuga canadensis* (L.) Carr.
B. Reproduction of trees listed above.	
Witch Hazel	*Hamamelis virginiana* L.
C. Wood Nettles	*Laportea canadensis* (L.) Gaud.
Blackberry	*Rubus allegheniensis* Porter
Jewelweed	*Impatiens pallida* Nutt.
Jack-in-the-Pulpit	*Arisaema triphyllum* (L.) Schott.
Violets	*Viola* spp.
Hepatica	*Hepatica triloba* Chaix.

II. Moist Woods

St. Mary's Pond

A. Red Maple	*Acer rubrum* L.
Hemlock	*Tsuga canadensis* (L.) Carr.
Black Ash	*Fraxinus nigra* Marsh.
Yellow Birch	*Betula lutea* Michx. f.
B. Fly Honeysuckle	*Lonicera canadensis* Marsh.
Canada Yew	*Taxus canadensis* Marsh.
Reproduction of trees above.	
Alternate-leaved Dogwood	*Cornus alternifolia* L. f.
C. Cinnamon Fern	*Osmunda cinnamomea* L.
Sensitive Fern	*Onoclea sensibilis* L.
Dwarf Ginseng	*Panax trifolium* L.
Mandrake	*Podophyllum peltatum* L.
Jewelweed	*Impatiens pallida* Nutt.
Coral Root	*Corallorrhiza maculata* Raf.

Constantia

A. Beech	*Fagus grandifolia* Ehrh.
Red Maple	*Acer rubrum* L.
Yellow Birch	*Betula lutea* Michx. f.
Blue Beech	*Carpinus caroliniana* Walt.
Hemlock	*Tsuga canadensis* (L.) Carr.
Basswood	*Tilia glabra* Vent.
American Elm	*Ulmus americana* L.
B. Moosewood	*Acer pennsylvanicum* L.
Witch Hobble	*Vibernum alnifolium* Marsh.
Canada Yew	*Taxus canadensis* Marsh.
Mountain Maple	*Acer spicatum* Lam.
Poison Ivy	*Rhus Toxicodendron* L.
Alternate-leaved Dogwood	*Cornus alternifolia* L. f.
C. Dwarf Ginseng	*Panax trifolium* L.
Cinnamon Fern	*Osmunda cinnamomea* L.
Yellow Clintonia	*Clintonia borealis* (Ait.) Raf.
Wood Nettle	*Laportea canadensis* (L.) Gaud.
Jack-in-the-Pulpit	*Arisaema triphyllum* (L.) Schott.
False Solomon's Seal	*Smilacina racemosa* (L.) Desf.
Ginseng	*Panax quinquefolium* L.
Wood Sorrel	*Oxalis Acetosella* L.

Mud Pond, Marcellus

A. Red Maple	*Acer rubrum* L.
American Elm	*Ulmus americana* L.
Black Ash	*Fraxinus nigra* Marsh.
Yellow Birch	*Betula lutea* Michx. f.
Hemlock	*Tsuga canadensis* (L.) Carr.
Cedar	*Thuja occidentalis* L.
Basswood	*Tilia glabra* Vent.
B. Poison Ivy	*Rhus Toxicodendron* L.
Wood Nettles	*Laportea canadensis* (L.) Gaud.
Spice Bush	*Benzoin aestivale* (L.) Nees.
Virginia Creeper	*Psedera quinquefolia* (L.) Greene
Canada Yew	*Taxus canadensis* Marsh.
C. Sensitive Fern	*Onoclea sensibilis* L.
Shield Fern	*Aspidium* sp.
Maidenhair Fern	*Adiantum pedatum* L.
Christmas Fern	*Polystichum acrostichoides* (Michx.) Schott.
Liverwort	Hepaticae
Dwarf Ginseng	*Panax trifolium* L.

Conquest

A. Red Maple	*Acer rubrum* L.
Black Ash	*Fraxinus nigra* Marsh.
Yellow Birch	*Betula lutea* Michx. f.
Bitternut Hickory	*Hicoria cordiformis* (Wang.) K. Koch.
Hemlock	*Tsuga canadensis* (L.) Carr.
Basswood	*Tilia glabra* Vent.
White Ash	*Fraxinus americana* L.
Cork Elm	*Ulmus racemosa* Thomas
B. Virginia Creeper	*Psedera quinquefolia* (L.) Greene
Spice Bush	*Benzoin aestivale* (L.) Nees.
Wild Grape	*Vitis* sp.
Sassafras	*Sassafras variifolium* (Salisb.) Ktze.
Alternate-leaved Dogwood	*Cornus alternifolia* L. f.
Wild Red Raspberry	*Rubus idaeus* var. *aculeatissimus* (C. A. Mey.) Regel & Tiling
Panicled Dogwood	*Cornus paniculata* L'Her.
Chokecherry	*Prunus virginiana* L.
Fly Honeysuckle	*Lonicera canadensis* Marsh.
C. Jewelweed (Pale)	*Impatiens pallida* Nutt.
Jewelweed (Spotted)	*Impatiens biflora* Walt.
Purple Nightshade	*Solanum Dulcamara* L.
Cinnamon Fern	*Osmunda cinnamomea* L.
Sensitive Fern	*Onoclea sensibilis* L.
Hay-scented Fern	*Dicksonia punctilobula* (Michx.) Gray
Wood Nettle	*Laportea canadensis* (L.) Gaud.
Mandrake	*Podophyllum peltatum* L.
Ground Hemlock	*Taxus canadensis* Marsh.
Skunk Cabbage	*Symplocarpus foetidus* (L.) Nutt.
Solomon's Seal	*Smilacina stellata* (L.) Desf.
Skunk Currant	*Ribes prostratum* L'Her.
Violets	*Viola* spp.

III. Meadow

Little Bay Creek, Brewerton

A. Trees absent.

B. Cat-tail	*Typha latifolia* (L.)
Sedges	Cyperaceae
Marsh Grasses	Gramineae

C. Very little ground cover beside plants listed in B.

South Pond, Constantia

A. Trees absent

B. A few widely scattered shrubs:

Tag Alder	*Alnus incana* (L.) Moench.
Hardhack	*Spirea tomentosa* L.
Dewberry	*Rubus villosus* Ait.
C. Goldenrod	*Solidago canadensis* L.
Daisy	*Chrysanthemum Leucanthemum* L.
Hawkweed	*Hieracium aurantiacum* L.
Sedges	Cyperaceae
Grasses	Gramineae
Sensitive Fern	*Onoclea sensibilis* L.
Strawberry	*Fragaria* sp.

Reservoir Outlet, Constantia

A. Trees absent

B. Shrubs along the brook somewhat scattered:

Willow	*Salix* sp.
Elderberry	*Sambucus canadensis* L.
Tag Alder	*Alnus incana* (L.) Moench.
C. Grasses	Gramineae
Sedges	Cyperaceae
Sensitive Fern	*Onoclea sensibilis* L.
Smartweed	*Persicaria Muhlenbergii* (Meisn.) Wats.
Blackberry	*Rubus* sp.

Crandall Creek, Constantia

A. Trees absent

B. Shrubs absent

C. Grasses	Gramineae
Cat-tail	*Typha latifolia* L.
Smartweed	*Persicaria Muhlenbergii* (Meisn.) Wats.
Joe Pye Weed	*Eupatorium purpureum* L.
Boneset	*Eupatorium perfoliatum* L.
Blue Flag	*Iris versicolor* L.
Cardinal Flower	*Lobelia cardinalis* L.
Teasel	*Dipsacus sylvestris* Huds.
Mint	*Mentha* sp.

Mud Pond, Marcellus

A. Trees absent

B. Shrubs very few and widely scattered:

Goldenrod	*Solidago canadensis* L.
Joe Pye Weed	*Eupatorium purpureum* L.
Boneset	*Eupatorium perfoliatum* L.
Willow Herb	*Epilobium hirsutum* L.
C. Horse Tail	*Equisetum* sp.
Grasses	Gramineae
Mint	*Mentha* sp.

Conquest

A. Hawthorn (scattered)	*Crataegus* sp.
B. Shrubs absent	
C. Marsh grasses	Gramineae
Goldenrod	*Solidago canadensis* L.
Daisy	*Chrysanthemum Leucanthemum* L.
Willow Herb	*Epilobium hirsutum* L.
Mints	*Mentha* spp.
Sensitive Fern	*Onoclea sensibilis* L.
Cardinal Flower	*Lobelia cardinalis* L.
Thistle	*Cirsium* sp.
Wild Strawberry	*Fragaria virginiana* Duchesne

IV. Woods-Meadow

Sadler's Woods, Brewerton

A. American Elm	*Ulmus americana* L.
Red Maple	*Acer rubrum* L.
White Cedar	*Thuja occidentalis* L.
B. Joe Pye Weed	*Eupatorium purpureum* L.
Boneset	*Eupatorium perfoliatum* L.
Goldenrod	*Solidago canadensis* L.
Poison Ivy	*Rhus Toxicodendron* L.
C. Cinnamon Fern	*Osmunda cinnamomea* L.
False Solomon's Seal	*Smilacina racemosa* (L.) Desf.
Grasses	Gramineae
Milkweed	*Asclepias* sp.

Mud Pond, Marcellus

A. Cedar	*Thuja occidentalis* L.
American Elm	*Ulmus americana* L.
Red Maple	*Acer rubrum* L.
B. Red-stemmed Dogwood	*Cornus stolonifera* Michx.
Willow	*Salix* sp.
Buckthorn	*Rhamnus cathartica* L.
Boneset	*Eupatorium perfoliatum* L.
Joe Pye Weed	*Eupatorium purpureum* L.
Goldenrod	*Solidago canadensis* L.
Clematis	*Clematis virginiana* L.
Dewberry	*Rubus villosus* Ait.
C. Smartweed	*Persicaria Muhlenbergii* (Meisn.) Wats.
Grasses	Gramineae
Horse Tail	*Equisetum* sp.
Blue Flag	*Iris versicolor* L.
Cardinal Flower	*Lobelia cardinalis* L.
Purple Nightshade	*Solanum Dulcamara* L.

Conquest

A. White Willow (few)	*Salix alba* L.
Black Ash (few)	*Fraxinus nigra* Marsh.
B. Goldenrod	*Solidago canadensis* L.
Swamp Milkweed	*Asclepias incarnata* L.
Cat-tail	*Typha latifolia* L.
C. Sedges	*Carex* spp.
Grass	Gramineae
Purple Nightshade	*Solanum Dulcamara* L.
Smartweed (water)	*Persicaria acre* H B K.
Catnip	*Nepeta Cataria* L.
Spearmint	*Mentha spicata* L.
Cardinal Flower	*Lobelia cardinalis* L.

V. Lesser Habitats

Brewerton

Sedges and cat-tails (Cyperaceae and Typha). These were practically the only forms of vegetation found in this habitat.

Mud Pond, Marcellus

Sweet flag (*Acorus Calamus* L.). This habitat was made up almost entirely of sweet flag with an occasional vine of purple nightshade (*Solanum Dulcamara* L.) where it could find a place to climb on an old stump or fence post. A species of grass (Gramineae) and a mint (*Mentha* sp.) were about the only other plants in evidence except for two small patches of Willow herb (*Epilobium hirsutum* L.).

Dogwood (*Cornus stolonifera* Michx.). This habitat was predominantly red-stemmed dogwood with a few white cedar (*Thuja occidentalis* L.), goldenrod (*Solidago canadensis* L.) and occasional small spots of grass (Gramineae).

St. Mary's Pond

Bog: The vegetation here was typical of most north country bogs, with a few shrubs such as bog rosemary (*Andromeda glaucophylla* Link), Labrador tea (*Ledum groenlandicum* Oeder.). Underfoot was a layer of moss (Spagnum).

Over most of it, various species of Orchidaceae and small cranberry (*Vaccinium Oxycoccos* L.) grew in profusion. Towards the edge, water fern (*Osmunda regalis* L.) was generally found in a narrow strip that soon gave way to tag alder *Alnus incana* (L.) Moench.

BIBLIOGRAPHY

Adams, L. E.
1909. Hypotheses as to cause of the Autumnal Epidemic of the Common and Lesser Shrew. Memoirs of Manchester Literary and Philosophical Soc., Vol. 54.

Allee, W. C.
1932. Animal Life and Social Growth. Pp. 1–160. Williams and Wilkins Co., Baltimore.

Allen, G. M.
1927. Dichromatism in a Litter of Red-backed Mice. Jour. Mammalogy, Vol. 8, No. 3, p. 248.

Anderson, R. M.
1932. Methods of Collecting and Preserving Vertebrate Animals. Bull. 69, Biol. Series 18, Nat. Mus. Canada, pp. 1–141. Ottawa.

Anthony, A. W.
1923. Periodical Emigrations of Mammals. Jour. Mammalogy, Vol. 4, No. 1, pp. 60–61.

Anthony, H. E.
1925. The Capture and Preservation of Small Mammals for Study. Amer. Mus. Nat. Hist. Guide Leaflet No. 61, pp. 1–54.
1928. Field Book of North American Mammals. Pp. 1–625. G. P. Putnam's Sons, N. Y.

Apgar, C. S.
1930. A Comparative Study of the Pelage of Three Forms of Peromyscus. Jour. Mammalogy, Vol. 11, No. 4, pp. 485–493.

Audubon, J. J., and Bachman, J.
1849. Quadrupeds of North America. Vol. 1, pp. 1–384.

Babcock, H. L.
1914. Some Observations on the Food Habits of the Short-tailed Shrew (*Blarina brevicauda*). Science, Vol. 40, No. 1032, pp. 526–530.

Bachman, J.
1837. Some Remarks on the Genus Sorex, with a Monograph of the North American Species. Jour. Acad. Nat. Sci., Philadelphia, Vol. 7, pp. 362–402.

Bailey, B.
1929. Mammals of Sherburne County, Minnesota. Jour. Mammalogy, Vol. 10, No. 2, pp. 153–164.

Bailey, V.
1897. Revision of the American Voles of Genus *Evotomys*. Proc. Biol. Soc. Washington, Vol. 11, pp. 113–138.
1900. Revision of American Voles of the Genus *Microtus*. N. A. Fauna, No. 17, pp. 1–88.
1921. Capturing Small Mammals for Study. Jour. Mammalogy, Vol. 2, No. 2, pp. 63–68.
1924. Breeding, Feeding and Other Life Habits of Meadow Mice (Microtus). Jour. Agric. Research, Vol. 27, pp. 523–535.

Baker, E. C. Stuart
1920. The Power of Scent in Wild Animals. Jour. Bombay Nat. Hist. Soc., Vol. 27, pp. 112–118.

Baker, J. R., and Ranson, R. M.
1932. Factors Affecting the Breeding of the Field Mouse (*Microtus agrestis*). Part 1. Light. Proc. Royal Soc. London, Series B, Vol. 110, pp. 313–322.

Bishop, S. C.
1923. Note on the Nest and Young of the Small Brown Weasel. Jour. Mammalogy, Vol. 4, No. 1, pp. 26–27.

Blake, I. H.
1931. Further Studies on Deciduous Forest Animal Communities. Ecology, Vol. 12, No. 3, pp. 508–527.

Borradaile, L. A.
1923. The Animal and Its Environment, a Textbook of the Natural History of Animals. Pp. 1–399. London.

Brimley, C. S.
1919. Our Rats, Mice and Shrews. (Popular descriptive account of the species occurring in North Carolina). Jour. of Elisha Mitchell Scientific Soc., pp. 55–60.

Brooks, F. E.
1908. Notes on the habits of Mice, Moles and Shrews. West Virginia University Agr. Exp. Sta., Bull. 113, pp. 89–133.

Brower, C. D.
1923. The Lemmings of Point Barrow, Alaska. Zool. Soc. Bull., Vol. 26, No. 1, p. 9.

Brown, L. P.
1923. Notes on a Few Mice, Rabbits and Other Animals. Jour. Mammalogy, Vol. 4, No. 4, pp. 258–260.

Brownell, L. W.
1924. Animal Trails and Trailing. Nature Mag., Vol. 3, No. 1, pp. 11–16.

Buck, C. W., Tolman, N., and Tolman, W.
1925. The Tail as a Balancing Organ in Mice. Jour. Mammalogy, Vol. 6, No. 4, pp. 267–271.

Burt, W. H.
1927. A simple Live Trap for Small Mammals. Jour. Mammalogy, Vol. 8, No. 4 pp. 302–304.

Cantwell, G. G.
1930. Preparing Mammal Skins in the Field. Jour. Mammalogy, Vol. 11, No. 3, pp. 324–325.

Chapin, J. P.
1922. Woodland Jumping Mouse near Tuxedo, New York. Jour. Mammalogy, Vol. 3, No. 2, p. 117.

Chapman, R. N.
1928. Temperature as an Ecological Factor in Animals. Amer. Nat., Vol. 62, pp. 298–310.
1929. Biotic Potential, Environmental Resistance, and Insect Abundance. Congress of International Zoology, Budapest, Vol. 2, pp. 1209–1218.

Chenoweth, H. E.
1917. Reactions of Certain Moist Forest Mammals to Air Conditions and its Bearing on Problems of Mammalian Distribution. Biol. Bull., Vol. 32, pp. 183–201.

Clench, W. J.
1925. Snails Eaten by Shrews. Nautilus, Vol. 39, No. 1, p. 28.

Coburn, C. A.
1922. Heredity of Wildness and Savageness in Mice. Behavior Monographs, Vol. 4, No. 5, Serial No. 21, pp. 4–71.

Cogshall, A. S.
1928. Food Habits of Deer Mice of the Genus Peromyscus in Captivity. Jour. Mammalogy, Vol. 9, No. 3, pp. 217–221.

Collins, H. H.
1923. Studies of the Pelage Phases and of the Nature of Color Variations in Mice of the Genus Peromyscus. Jour. Experimental Zool., Vol. 38, pp. 45–107.

Cope, E. D.
1873. On a Habit of a Species of Blarina. (Account of captive Blarina killing and eating water snake.) Amer. Naturalist, Vol. 7, pp. 490–491.

Copley, H.
1921. Power of Scent in Wild Animals. Jour. Bombay Nat. Hist. Soc., Vol. 28, pp. 262–265.

Couch, L. K.
1924. Mice and Moles. Jour. Mammalogy, Vol. 5, No. 4, p. 264.
1925. Storing Habits of *Microtus townsendii*. Jour. Mammalogy, Vol. 6, No. 3, pp. 200–201.
1927. Migrations of the Washington Black-tailed Jack Rabbit. Jour. Mammalogy, Vol. 8, No. 4, pp. 313–314.

Dice, L. R.
1922. Some Factors Affecting the Distribution of the Prairie Vole, Forest Deer Mouse, and Prairie Deer Mouse. Ecology, Vol. 3, pp. 29–47.
1923. Notes on the Communities of Vertebrates of Riley County, Kansas, with special reference to Amphibians, Reptiles, and Mammals. Ecology, Vol. 4, pp. 40–53.
1923a. Notes on Some Mammals of Riley County, Kansas. Jour. Mammalogy, Vol. 4, No. 2, pp. 107–112.
1927. A Manual of the Recent Wild Mammals of Michigan. Michigan Handbook Series, No. 2, Univ. Mich., pp. 1–62.
1929. A New Laboratory Cage for Small Mammals, with Notes on Methods of Rearing Peromyscus. Jour. Mammalogy, Vol. 10, No. 2, pp. 116–124.
1931. The Occurrence of Two Subspecies of the Same Species in the Same Area. Jour. Mammalogy, Vol. 12, No. 3, pp. 210–213.
1931a. Methods of Indicating the Abundance of Mammals. Jour. Mammalogy, Vol. 12, No. 4, pp. 376–381.
1932. Variation in a Geographic Race of the Deer Mouse, *Peromyscus maniculatus bairdii*. Occ. Papers Mus. Zool., Univ. Mich., No. 239, pp. 1–26.
1932a. The Songs of Mice. Jour. Mammalogy, Vol. 13, No. 3, pp. 187–196.
1933. Longevity in *Peromyscus maniculatus gracilis*. Jour. Mammalogy, Vol. 14, No. 2, pp. 147–148.

Dice, L. R., and Sherman, H. B.
1922. Notes on the Mammals of Gogebic and Ontonagon Counties, Michigan, 1920. Occ. Papers Mus. Zool., Univ. Mich., No. 109, pp. 1–46.

Edison, J. M.
1932. Hibernation of the Northwest Jumping Mouse. Murrelet, Vol. 13, No. 2, pp. 55–56.

Elton, C. S.
1924. Periodic Fluctuations in the Numbers of Animals: Their causes and effects. Brit. Jour. Exp. Biol., Vol. 2, pp. 119–163.
1925. Plague and the Regulations of Numbers in Wild Mammals. Jour. Hygiene, Vol. 24, pp. 138–163.

Enders, R. K.
1930. Some Factors Influencing the Distribution of Mammals in Ohio. Occ. Papers Mus. Zool., Univ. Mich., No. 212, pp. 1–27.

Fraleigh, L. B.
1929. The Habits of Mammals at an Adirondack Camp. N. Y. State Museum Handbook 8, pp. 119–169.

Gadow, Hans
1913. The Wanderings of Animals. Pp. 1–150. Cambridge Univ. Press.

Gillman, H.
1876. Sensitiveness to Sound in the Shrew. Amer. Nat., Vol. 10, pp. 430–431.

Gilpin, J. B.
1870. On the Mammals of Nova Scotia. Trans. Nova Scotia Inst. Nat. Sci., Vol. 2, p. 8.

Goodwin, G. G.
1924. Mammals of the Gaspe Peninsula, Quebec. Jour. Mammalogy, Vol. 5, No. 4, pp. 247–257.
1929. Mammals of the Cascapedia Valley, Quebec. Jour. Mammalogy, Vol. 10, No. 3, pp. 239–246.
1929a. An Unusually Long-tailed White-footed Mouse. Jour. Mammalogy, Vol. 10, No. 4, p. 352.
1932. New Records and Some Observations on Connecticut Mammals. Jour. Mammalogy, Vol. 13, No. 1, pp. 36–40.

Gossard, H. A.
1923. Ohio Records of the Jumping Mouse. Ohio Jour. Sci., Vol. 23, No. 5, pp. 284–286.

Graham, S. A.
1928. The Influence of Small Mammals and Other Factors upon the Larch Sawfly Survival. Jour. Econ. Entomol., Vol. 21, pp. 301–310.
1929. The Larch Sawfly as an Indicator of Mouse Abundance. Jour. Mammalogy, Vol. 10, No. 3, pp. 189–196.

Green, C. V.
1933. Differential Growth in the Crania of Mature Mice. Jour. Mammalogy, Vol. 14, No. 2, pp. 122–131.

Green, M. M.
1925. Notes on Some Mammals of Montmorency County, Michigan. Jour. Mammalogy, Vol. 6, No. 3, pp. 173–178.
1926. Notes on Some Saskatchewan Voles. Canadian Field Naturalist, Vol. 40, pp. 142–143.

Gregory, Tappan
1928. A Few White-footed Mouse Pictures. Jour. Mammalogy, Vol. 9, No. 3, pp. 205–208.

Hahn, W. L.
1909. The Mammals of Indiana. Ind. Dept. Geol. and Nat. Resources, 33rd Ann. Rept., pp. 417–663.

Hall, E. R.
1928. Note on the Life History of the Woodland Deer Mouse. Jour. Mammalogy, Vol. 9. No. 3, pp. 255-256.

Hamilton, C. C.
1917. The Behavior of Some Soil Insects in Gradients of Evaporating Power of Air, Carbon Dioxide and Ammonia. Biol. Bull. 32, pp. 159–182.

Hamilton, W. J., Jr.
1929. Breeding Habits of the Short-tailed Shrew, *Blarina brevicauda*. Jour. Mammalogy, Vol. 10, No. 2, pp. 125–134.
1930. The Food of the Soricidae. Jour. Mammalogy, Vol. 11, No. 1, pp. 26–39.
1931. Habits of the Short-tailed Shrew, *Blarina brevicauda* (Say). The Ohio Jour. Sci., Vol. 31, No. 2, pp. 97–106.
1931a. Habits of the Star-nosed Mole, *Condylura cristata*. Jour. Mammalogy, Vol. 12, No. 4, pp. 345–355.

Harper, F.
1929. Notes on Mammals of the Adirondacks. N. Y. State Museum Handbook 8, pp. 51–118.

Harper, F., and Harper, J. S.
1929. Animal Habitats in Certain Portions of the Adirondacks. N. Y. State Museum Handbook 8, pp. 11–49.

Harris, G. W.
1923. A Waltzing Mouse. Nature, Vol. 112, p. 939.

Harting, J. E., and others.
1893. Report of the Departmental Committee on a Plague of Field Voles in Scotland. London (In Parliamentary Papers, 1893–1894, 73).

Hatt, R. T.
1923. Notes on Some Captive Deer-mice. Jour. Mammalogy, Vol. 4, No. 3, pp. 186–187.
1924. The Land Vertebrate Communities of Western Leelanau County, Michigan, with an Annotated List of the Mammals of the County. Papers Mich. Acad. Sci., Arts, and Letters, Vol. 3, pp. 369–402.
1925. A New Live-trap for Field Use. Jour. Mammalogy, Vol. 6, No. 3, pp. 178–181.
1928. The Relation of the Meadow Mouse, *Microtus p. pennsylvanicus* to the Biota of a Lake Champlain Island. Ecology, Vol. 9, pp. 88–93.
1930. The Biology of the Voles of New York. Roosevelt Wild Life Bull., Vol. 5, No. 4, pp. 513–623.

Heape, W.
1931. Emigration, Migration and Nomadism. Pp. 1–369. W. Heffer and Sons, Cambridge.

Henderson, A. D.
1923. Cycles of Abundance and Scarcity in Certain Mammals and Birds. Jour. Mammalogy, Vol. 4, No. 4, pp. 264–265.

Hinton, M. A. C.
1926. Monograph of the Voles and Lemmings (Microtina). Vol. 1, Brit. Mus. Nat. Hist., London.

Howell, A. B.
1920. A Study of the California Jumping Mice of the Genus Zapus. Univ. of Cal. Publ. Zool., Vol. 21, No. 5, pp. 225–238.
1922. Agencies Which Govern the Distribution of Life. Amer. Nat., Vol. 56, pp. 428–438.
1923. Periodic Fluctuations in the Numbers of Small Mammals. Jour. Mammalogy, Vol. 4, No. 3, pp. 149–155.
1924. Theories of Distribution—A Critique. Ecology, Vol. 5, pp. 51–53.
1924a. Individual and Age Variation in *Microtus montanus yosemite*. Jour. Agri., Research, Vol. 28, No. 10, pp. 977–1016.

Hudson, W. H.
1892. The Naturalist in La Plata. "A Wave of Life". Chapter 3. London.

Huestis, R. R.
1923. The Heredity of Microscopic Hair Characters in Peromyscus. Proceed. Nat. Acad. Sci., Vol. 9, pp. 352–355.
1925. A Description of Microscopic Hair Characters and of their Inheritance in Peromyscus. Jour. Experimental Zool., Vol. 41, pp. 429–470.
1931. Seasonal Pelage Differences in Peromyscus. Jour. Mammalogy, Vol. 12, No. 4, pp. 372–375.
1932. Local differences in Pelage Characters of Peromyscus. Jour. Mammalogy, Vol. 13, No. 3, pp. 210–218.
1933. Maternal Behavior in the Deer Mouse. Jour. Mammalogy, Vol. 14, No. 1, pp. 47–49.

Huntington, E.
1931. The Matamek Conference on Biological Cycles, 1931. Science, N. S., Vol. 74, No. 1914, pp. 229–235.

Huxley, Julian
1927. Mice and Men. Harper's Magazine, Vol. 156 (December), pp. 42–50.

Jackson, H. H. T.
1920. An Apparent Effect of Winter Inactivity upon Distribution of Mammals. Jour. Mammalogy, Vol. 1, No. 2, pp. 58–65.
1928. A Taxonomic Review of the American Long-tailed Shrews (genera Sorex and Microsorex). N. A. Fauna, No. 51, U. S. Dept. Agric., Bur. Biol. Survey, pp. 1–238.

Johnson, B. W.
1924. A Preliminary Study of the Mice of Mount Desert Island. Anat. Record, Vol. 29, pp. 1–130.
1927. Preliminary Experimental Studies of Mice of Mount Desert Island, Maine. Jour. Mammalogy, Vol. 8, No. 4, pp. 276–284.

Johnson, C. E.
1926. The Cooperation of Forestry in Game Management. Bull. N. Y. State Fish, Game and Forest League, pp. 8–12 (December).

Johnson, M. S.
1926. Activity and Distribution of Certain Wild Mice in Relation to Biotic Communities. Jour. Mammalogy, Vol. 7, No. 4, pp. 245–277.

Kirk, G. L.
1921. Shrews and Weasels. Jour. Mammalogy, Vol. 2, No. 2, p. 111.

Klugh, A. B.
1921. Notes on the Habits of *Blarina brevicauda*. Jour. Mammalogy, Vol. 2, No. 1, p. 35.
1930. Presenting Blarina. Nature Mag., Vol. 15, No. 4, pp. 241–243.

Komarek, E. V.
1932. Notes on Mammals of Menominee Indian Reservation, Wisconsin. Jour. Mammalogy, Vol. 13, No. 3, pp. 203–209.

Lantz, D. E.
1905. Meadow Mice in Relation to Agriculture and Horticulture. Yearbook of U. S. Dept. of Agric., pp. 363–376.
1907. An Economic Study of Field Mice. U. S. Dept. Agric., Biol. Survey Bull. No. 31, pp. 1–64.
1918. Rodent Pests of the Farm. U. S. Dept. of Agric., Farmer's Bull. No. 932, pp. 1–23.
1918a. Field Mice as Farm and Orchard Pests. U. S. Dept. Agric., Farmer's Bull. No. 670, pp. 1–12.

Lincoln, F. C.
1923. White-footed Mice as Camp Companions. Jour. Mammalogy, Vol. 4, No. 3, pp. 185–186.

Locke, S. B.
1930. The Study of Big Game Ranges. Ecology, Vol. 11, No. 4, p. 770.

Lyon, M. W.
1922. Notes on the Mammals of the Dune Region of Porter County, Indiana. Proc. Indiana Acad. Sci., pp. 209–221.

MacDowell, E. C., and Lord, E. M.
1925. Data on the Primary Sex Ratio in the Mouse. Anat. Record, Vol. 31, pp. 143–148.

Mailliard, J.
1923. Further Notes on the Birds and Mammals of Siskiyon county, California. Proc. Calif. Acad. Sci., Ser. 4, Vol. 13, No. 3, pp. 7–28.
1923a. Field Work among the Birds and Mammals of the Northern Coast of California in 1921. Proc. Calif. Acad. Sci., Ser. 4, Vol. 12, No. 1, pp. 1–26.
1925. Notes upon the Numerical Status of Rodent Populations in Parts of California. Jour. Mammalogy, Vol. 6, No. 2, pp. 102–105.

McNair, G. T.
1931. The Deer Mouse, Peromyscus, a Valuable Laboratory Mammal. Jour. Mammalogy, Vol. 12, No. 1, pp. 48–52.

Mearns, E. A.
1898. Notes on the Mammals of the Catskill Mountains, N. Y., with general remarks on the Fauna and Flora of the Region. Proc. U. S. Nat. Mus., Vol. 21, pp. 341–360.

Merriam, C. H.
1886. The Mammals of the Adirondack Region. Pp. 1–316. New York.
1895. Revision of the Shrews of the American Genera Blarina and Notiosorex. N. A. Fauna No. 10, U. S. Dept. Agric., Div. Ornithol. and Mammalogy, pp. 5–34.

Middleton, A. D.
1930. Cycles in the Numbers of British Voles (*Microtus*). Jour. Ecology, Vol. 18, pp. 156–165.

Miller, G. S.
1899. Preliminary List of New York Mammals. Bull. N. Y. State Museum, Vol. 6, No. 29, pp. 273–390.

Montgomery, T. H.
1899. Observations on Owls, with particular regard to their Feeding Habits. Amer. Nat., Vol. 33, pp. 563–572.

Moody, P. A.
1929. Brightness Vision in the Deer-Mouse, *Peromyscus maniculatus gracilis*. Jour. Experimental Zool., Vol. 52, pp. 367–405.

Moseley, E. L.
1930. Feeding a Short-tailed Shrew. Jour. Mammalogy, Vol. 11, No. 2, pp. 224–225.

Murie, A.
1933. The Ecological Relationship of Two Subspecies of *Peromyscus* in the Glacier Park Region, Montana. Occ. Papers Mus. Zool., Univ. of Mich., No. 270, pp. 1–17.

Murie, O. J., and Murie, A.
1931. Travels of Peromyscus. Jour. Mammalogy, Vol. 12, No. 3, pp. 200–209.
1932. Further Notes on Travels of Peromyscus. Jour. Mammalogy, Vol. 13, No. 1, pp. 78–79.

Nelson, E. W.
1930. Wild Animals of North America. Nat. Geog. Soc., pp. 1–253, Washington, D. C.

Norton, A. H.
1930. The Mammals of Portland, Maine, and Vicinity. Proc. Portland Soc. Nat. Hist., Vol. 4, pt. 1, pp. 1–151.

Orr, R. T.
1933. Aquatic Habits of *Peromyscus maniculatus*. Jour. Mammalogy, Vol. 14, No. 2, pp. 160–161.

Osgood, W. H.
1909. Revision of the Mice of the American Genus Peromyscus. N. A. Fauna No. 28, U. S. Dept. Agric., Bur. Biol. Survey, pp. 9–285.

Palmer, T. S.
1928. An Earlier Name for the Genus *Evotomys*. Proc. Biol. Soc. Washington, Vol. 41, pp. 87–88.

Parkes, A. S.
1924. Fertility in Mice. British Jour. Experimental Biol., Vol. 2, No. 1, pp. 21–31.

Paulmier, F. C.
1904. The Squirrels and Other Rodents of the Adirondacks. Ninth Report, N. Y. State Forest, Fish and Game Comm., pp. 339–351.

Pearce, John
1934. Albinism in the Cinereous Shrew. Jour. Mammalogy, Vol. 15, No. 1, p. 67.

Pearse, A. S.
1922. The Effects of Environment on Animals. Amer. Nat., Vol. 56, pp. 144–158.

Perrin, E. O.
1920. On the Trail of a Deer-mouse. Forest and Stream, Vol. 90, pp. 306–307.

Phillips, J. F. V.
1931. Quantitative Methods in the Study of Numbers of Terrestrial Animals in Biotic Communities: A Review, with Suggestions. Ecology, Vol. 12, No. 4, pp. 633–649.

Piper, Stanley E.
1909. Mouse Plagues, their Control and Prevention. Yrbk. U. S. Dept. Agric., 1908, pp. 301–310.
1909a. The Nevada Mouse Plague of 1907–08. U. S. Dept. Agric., Farmer's Bull. No. 352, pp. 1–23.

Pitt, F.
1930. The Lemming Hordes of Norway. Field, Vol. 156, No. 4046, p. 56. London.

Powers, E. B.
1925. The Singing of the House Mouse. Jour. Mammalogy, Vol. 6, No. 3, p. 201.

Preble, E. A.
1899. Revision of the Jumping Mice of the Genus Zapus. N. A. Fauna No. 15, U. S. Dept. Agri. (Bur. Biol. Survey No. 5), pp. 1–39.

Rhoads, S. N.
1903. The Mammals of Pennsylvania and New Jersey. Pp. 1–266. Philadelphia.

Roosevelt, Theodore
1907. "Small Country Neighbors." Scribner's Magazine; October, Vol. 42, No. 4, p. 385.

Russell, C. P.
1925. Deer Migrations. Yosemite Nature Notes, Vol. 4, pp. 20–23.
1931. Seasonal Migration of Mule Deer. Ecol. Monogr., Vol. 2, No. 1, pp. 1–46.

Ryder, J. A.
1890. The Eye, Ocular Muscles and Lachrymal Glands of the Shrew Mole (*Blarina talpoides* Gray). Proc. Amer. Phil. Soc., Vol. 28, pp. 16–18.

Sanborn, C. C.
1926. Mammals of the Chicago Area. Field Mus. Nat. Hist., Zool. Leaflet 8, pp. 1–23.
1930. Notes from Northern and Central Illinois. Jour. Mammalogy, Vol. 11, No. 2, pp. 222–223.

Saunders, W. E.
1921. Notes on Napaeozapus. Jour. Mammalogy, Vol. 2, No. 4, pp. 237–238.
1929. The Smoky Shrew at London, Ontario. Canadian Field Naturalist, Vol. 43, p. 42.

Scheffer, T. H.
1924. Notes on the Breeding of Peromyscus. Jour. Mammalogy, Vol. 5, No. 4, pp. 258–260.

Schmidt, E. J. W.
1931. Mammals of Western Clark County, Wisconsin. Jour. Mammalogy, Vol. 12, No. 2, pp. 99–117.

Selle, R. M.
1928. *Microtus californicus* in Captivity. Jour. Mammalogy, Vol. 9, No. 2, pp. 93–98.

Seton, E. T.
1909. Life-Histories of Northern Animals. Vols. 1 and 2, pp. 1–1267. Chas. Scribner and Sons, N. Y.
1920. Notes on the Breeding Habits of Captive Deer Mice. Jour. Mammalogy, Vol. 1, No. 3, pp. 134–138.
1920a. For a Methodic Study of Life-Histories of Mammals. Jour. Mammalogy, Vol. 1, No. 2, pp. 67–69.
1920b. The Mole-mouse, Potato-mouse or Pine-mouse. Jour. Mammalogy, Vol. 1, No. 4, p. 185.

Shaw, W. T.
1924. The Red-backed Mouse as a Tree Inhabiter. Jour. Mammalogy, Vol. 5, No. 4, pp. 268–269.

Shelford, V. E.
1913. Animal Communities in Temperate America. Pp. 1–362. Univ. of Chicago Press.
1913a. The Reaction of Certain Animals to Gradients of Evaporating Power of Air. A study in Experimental Ecology. Biol. Bull., Vol. 25, pp. 79–120.
1929. Laboratory and Field Ecology. The Responses of Animals as Indicators of Correct Working Methods. Pp. 1–55. Williams and Wilkins Co. Baltimore.
1932. Basic Principles of the Classification of Communities and Habitats and the Use of Terms. Ecology, Vol. 13, No. 2, pp. 105–120.

Shufeldt, R. W.
1920. Weasels and their Habits. Amer. Forestry, Vol. 26, pp. 163–169.

Shull, A. F.
1907. Habits of the Short-tailed Shrew, *Blarina brevicauda* (Say). Amer. Nat., Vol. 41, pp. 495–552.
1932. Principles of Animal Biology. Pp. 1–441. McGraw and Hill.

Silver, J.
1924. Rodent Enemies of Fruit and Shade Trees. Jour. Mammalogy, Vol. 5, No. 3, pp. 165–173.
1924a. Mouse Control in Field and Orchard. U. S. Dept. Agric. Farmer's Bull. No. 1397, pp. 1–14.

Simpson, S. E.
1923. The Nest and Young of the Star-nosed Mole (*Condylura cristata*). Jour. Mammalogy, Vol. 4, No. 2, pp. 167–171.

Skinner, M. P.
1925. Migration Routes of Elk in Yellowstone National Park. Jour. Mammalogy, Vol. 6, No. 3, pp. 184–192.

Snyder, L. L.
1924. Some Details on the Life History and Behavior of *Napaeozapus insignis abietorum* (Preble). Jour. Mammalogy, Vol. 5, No. 4, pp. 233–237.

Soper, J. D.
1923. The Rare *Napaeozapus insignis*. Jour. Mammalogy, Vol. 4, No. 2, p. 127.
1923a. The Mammals of Wellington and Waterloo Counties, Ontario. Jour. Mammalogy, Vol. 4, No. 4, pp. 244–252.

Stone, W., and Cram, W. E.
1919. American Animals. Pp. 1–318. Doubleday, Page and Co.

Stoner, D.
1918. The Rodents of Iowa. Iowa Geol. Surv. Bull. 5, pp. 1–172.

Sudworth, G. D.
1927. Check List of the Forest Trees of the United States, their Names and Ranges. U. S. Dept. Agri., Misc. Cir. 92, pp. 1–295.

Sumner, F. B.
1909. Some Effect of External Conditions upon the White Mouse. Jour. Exper. Zool., Vol. 7, pp. 97–155.
1921. Desert and Lava-dwelling Mice, and the Problem of Protective Coloration in Mammals. Jour. Mammalogy, Vol. 2, No. 2, pp. 75–86.
1923. Results of Experiments in Hybridizing Subspecies of Peromyscus. Jour. Exper. Zool., Vol. 38, pp. 245–292.
1923a. Size-factor and Size-Inheritance. Proc. Nat. Acad. Sci., Vol. 9, pp. 391–397.
1926. An Analysis of Geographic Variation in Mice of the *Peromyscus polionotus* Group from Florida and Alabama. Jour. Mammalogy, Vol. 7, No. 3, pp. 149–184.
1927. Linear and Colorimetric Measurements of Small Mammals. Jour. Mammalogy, Vol. 8, No. 3, pp. 177–206.
1928. Continuation of Ecological and Genetical Studies with Peromyscus. Carnegie Institute of Washington, Yearbook No. 27, pp. 335–339.

Sumner, F. B., and Collins, H. H.
1922. Further Studies of Color Mutations in Mice of the Genus Peromyscus. Jour. Exper. Zool., Vol. 36, pp. 289–321.

Sumner, F. B., McDaniel, M. E., and Huestis, R. R.
1922. A Study of Influences which may affect the Sex-Ratio of the Deer-Mouse (*Peromyscus*). Biol. Bull., Vol. 43, pp. 123–165.

Sumner, F. B., and Swarth, H. S.
1924. The Supposed Effects of the Color Tone of the Background upon the Coat Color of Mammals. Jour. Mammalogy, Vol. 5, No. 2, pp. 81–113.

Sumner, F. B., and Karol, J. J.
1929. Notes on the Burrowing Habits of *Peromyscus polionotus*. Jour. Mammalogy, Vol. 10, No. 3, pp. 213–215.

Surber, Thaddeus
1923. The Occurrence of the Woodland Jumping Mouse in Minnesota. Fins, Feathers, and Fur, No. 35, p. 106.

Svihla, A.
1930. Breeding Habits and Young of the Red-backed Mouse, *Evotomys*. Papers Mich. Acad. Science, Arts and Letters, Vol. 11, pp. 485–489.
1932. A Comparative Life History Study of the Mice of the Genus Peromyscus. Univ. of Mich. Mus. of Zool., Misc. Pub. No. 24, pp. 1–39.

Svihla, A., and Svihla, R. D.
1933. Notes on the Jumping Mouse *Zapus trinotatus trinotatus* Rhoads. Jour. Mammalogy, Vol. 14, No. 2, pp. 131–134.

Svihla, R. D.
1932. The Ecological Distribution of the Mammals of the North Slope of the Uinta Mountains. Ecol. Monogr. Vol. 2, No. 1, pp. 47–81.

Taylor, W. P.
1919. Suggestions for Field Studies of Mammalian Life-Histories. U. S. Dept. of Agric., Dept. Cir. 59, pp. 1–8.
1920. A Novel Nesting Place of the Red-backed Mouse. Jour. Mammalogy, Vol. 1, No. 2, p. 92.
1930. Outlines for Studies of Mammalian Life Histories. Misc. Publ. 86, U. S. Dept. Agric., pp. 1–12.
1930a. Methods of Determining Rodent Pressure on the Range. Ecology, Vol. 11, No. 3, pp. 523–542.

Thomson, A. L.
1926. Problems of Bird-Migration. Pp. 1–350. Houghton, Mifflin and Co.

Townsend, M. T., and Smith, M.
1933. Ecology of the White-tailed Deer in the Adirondacks. Roosevelt Wild Life Bull., Vol. 6, No. 2, pp. 247–325.

Weese, A. O.
1924. Animal Ecology of an Illinois Elm-Maple Forest. Ill. Biol. Monogr., Vol. 9, No. 4, pp. 1–93.

Weydemeyer, W.
1928. Local Change in Migrating Habits of the Mule Deer. Jour. Mammalogy, Vol. 9, No. 3, pp. 209–212.

Williams, S. H.
1930. The Mammalian Fauna of Pennsylvania. Annals Carnegie Mus., Vol. 19, pp. 225–234.

Wilson, A.
1931. Insects and their Control. Pp. 1–369. Interstate Printing Corporation, Plainfield, N. J.

Wood, F. E.
1910. A Study of the Mammals of Champaign County, Illinois. Bull. Ill. State Lab. Nat. Hist., Vol. 8, pp. 501–613.

Wood, N. A.
1912. Notes on Michigan Mammals. 14th Report Mich. Acad. Sci., pp. 163–164.
1917. Notes on the Mammals of Alger County, Michigan. Occ. Papers Mus. Zool., Univ. Mich., No. 36, pp. 1–8.
1922. The Mammals of Washtenaw County, Michigan. Occ. Papers Mus. Zool., Univ. Mich., No. 123, pp. 1–23.
1922a. Notes on the Mammals of Berrien County, Michigan. Occ. Papers Mus. Zool., Univ. Mich., No. 124, pp. 1–4.

Wyman, L. C.
1922. The Validity of the Penobscot Field Mouse. Jour. Mammalogy, Vol. 3, No. 3, pp. 162–166.
1927. Side-lights on the Mouse Invasion. Museum Graphic (Los Angeles), Vol. 1, No. 4, pp. 140–142.

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ROOSEVELT WILD LIFE BULLETIN, Vol. 6, No. 2. October, 1933.

1. The White-tailed Deer of the Adirondacks.
   Part 1. Preliminary Survey of the White-tailed Deer of the Adirondacks.
   M. T. Townsend and M. W. Smith.
   Part 2. Ecology of the White-tailed Deer in Summer with Special Reference to the Adirondacks ..... M. T. Townsend and M. W. Smith.
2. Some Late Winter and Early Spring Observations on the White-tailed Deer of the Adirondacks ..... Chas. J. Spiker.

ROOSEVELT WILD LIFE BULLETIN, Vol. 6, No. 3. July, 1935.

1. A Popular Account of the Bird Life of the Finger Lakes Section of New York, with Main Reference to the Summer Season..... Chas. J. Spiker.

ANNALS

ROOSEVELT WILD LIFE ANNALS, Vol. 2, No. 1. January, 1929.

1. The Red Squirrel: Its Life History and Habits, with Special Reference to the Adirondacks of New York and the Harvard Forest..... R. T. Hatt.

ROOSEVELT WILD LIFE ANNALS, Vol. 2, No. 2. October, 1929.

1. The Ecology of Trout Streams in Yellowstone Park..... Richard A. Muttkowski.
2. The Food of Trout Stream Insects in Yellowstone Park.
   Richard A. Muttkowski and Gilbert M. Smith.

ROOSEVELT WILD LIFE ANNALS, Vol. 2, Nos. 3 and 4 (Double Number). January, 1932.

1. Ornithology of the Oneida Lake Region; With Reference to the Late Spring and Summer Seasons ..... Dayton Stoner.

ROOSEVELT WILD LIFE ANNALS, Vol. 3, No. 1. January, 1932.

1. Parasites of Oneida Lake Fishes. Part I. Descriptions of New Genera and New Species ..... H. J. Van Cleave and J. F. Mueller.

ROOSEVELT WILD LIFE ANNALS, Vol. 3, No. 2. October, 1932.

1. Parasites of Oneida Lake Fishes. Part II. Descriptions of new species and some general taxonomic considerations, especially concerning the trematode family Heterophyidae ..... Justus F. Mueller and Harley J. Van Cleave.
2. Trichodina renicola (Mueller, 1931), a ciliate parasite of the Urinary bladder of Esox Niger ..... Justus F. Mueller.

ROOSEVELT WILD LIFE ANNALS, Vol. 3, Nos. 3 and 4 (Double Number). July, 1934.

1. Parasites of Oneida Lake Fishes.
   Part 3. A Biological and Ecological Survey of the Worm Parasites.
   H. J. Van Cleave and Justus F. Mueller.
   Part 4. Additional Notes on Parasites of Oneida Lake Fishes, including Descriptions of New Species ..... Justus F. Mueller.